

**FINAL REPORT**

**ROCKY INTERTIDAL RESOURCE MONITORING  
AT THE CABRILLO NATIONAL MONUMENT, SAN DIEGO,  
TWO MONTHS AFTER CESSATION OF THE POINT LOMA  
WASTEWATER PLANT UNDERSEA PIPELINE SEWAGE SPILL**

*Prepared by:*

John M. Engle, Ph.D.  
7554 Palos Verdes Drive  
Goleta, CA 93117

*Submitted to:*

Mr. Alan C. Langworthy, Deputy Director  
Metropolitan Wastewater Division  
San Diego Water Utilities Department  
4077 North Harbor Drive  
San Diego, CA 92101

August 1992

## TABLE OF CONTENTS

LIST OF TABLES .....	ii
LIST OF FIGURES.....	iii
ABSTRACT.....	1
INTRODUCTION .....	2
METHODS.....	4
RESULTS .....	7
DISCUSSION .....	13
ACKNOWLEDGMENTS.....	16
LITERATURE CITED .....	17

## LIST OF TABLES

1. Intertidal natural resources and monitoring techniques in Cabrillo National Monument, California .....	19
2. June 1992 Goose barnacle data for 9 band transects .....	20-23
3. Goose barnacle summary data.....	24
4. Size distribution of goose barnacle clumps in 9 transects during June 1992 .....	25-26
5. Size distribution of individual goose barnacles within clumps in 1 x 10 m band transects .....	27
6. Goose barnacle size distribution summary table.....	28
7. June 1992 intertidal cover data for 45 photoplots (50 x 75 cm).....	29
8. Photoplot species summary data .....	30
9. June 1992 owl limpet data for 18 circular plots .....	31-33
10. Owl limpet summary data for individual circular plots .....	34
11. Owl limpet summary data for different habitats .....	35
12. Size distribution of owl limpets in 18 circular plots during June 1992 .....	36-37
13. Relative abundance of woolly sculpins in tidepools in June 1992 .....	38
14. Woolly sculpin summary data .....	39
15. Abundance and distribution of ground cover along 10 m line-intercept transects in June 1992 .....	40
16. Line intercept species summary data .....	41
17. Abundance of abalone and sea stars recorded during 30 min timed searches in June 1992.....	42
18. Abalone and sea star summary data.....	43
19. Summary of intertidal resource trends at Cabrillo National Monument: Spring 1990 to June 1992 .....	44

## LIST OF FIGURES

1. Public access and visitor use areas in Cabrillo National Monument, California.....	45
2A. Total area of goose barnacle clumps surveyed by band transects .....	46
2B. Average size of goose barnacle clumps surveyed by band transects .....	46
3A. Total number of goose barnacle clumps surveyed by band transects .....	47
3B. Number of small versus large barnacle clumps surveyed by band transects .....	47
4. Goose barnacle clump size-frequencies for each of three areas during six seasonal surveys from 1990 to 1992 .....	48-50
5A. Percent cover of acorn and thatched barnacles surveyed by barnacle photoplots .....	51
5B. Percent cover of other plants surveyed by barnacle photoplots.....	51
6A. Percent cover of rockweed surveyed by rockweed photoplots .....	52
6B. Percent cover of California mussels surveyed by mussel photoplots .....	52
7A. Total number of owl limpets surveyed by circular plots .....	53
7B. Average size of owl limpets surveyed by circular plots .....	53
8. Owl limpet length frequencies for each of three areas during six seasonal surveys from 1990 to 1992 .....	54-56
9A. Relative abundance of woolly sculpins in pools at Cabrillo National Monument in Spring 1992 .....	57
9B. Relative abundance of woolly sculpins in pools at Cabrillo National Monument in June 1992.....	57
10A. Percent Cover of red algal turf surveyed by turf line transects .....	58
10B. Percent cover of feather boa kelp surveyed by kelp line transects.....	58
11A. Percent cover of surf grass surveyed by grass line transects .....	59
11B. Percent cover of surf grass surveyed by kelp line transects .....	59

## ABSTRACT

On February 2, 1992, a catastrophic rupture occurred in San Diego's wastewater discharge pipeline 0.6 mi offshore in 35 ft of water. For the following two months, approximately 180 million gallons per day of treated sewage effluent spilled into the nearshore marine environment of Point Loma, including the western shore of the nearby Cabrillo National Monument. The National Park Service has been monitoring key intertidal resources at the Monument semi-annually since Spring 1990. Their Spring 1992 survey took place during April 11-13, one week after cessation of the spill. This report presents the findings of an additional follow-up survey for the San Diego Water Utilities Department, conducted on June 2-5, two months after the spill ended. In order to determine if the spill impacted rocky intertidal habitats within the Monument, the same National Park Service methodology was used to assess representative plant, invertebrate, and fish populations. Results were compared with all previous monitoring. Fourteen index taxa were surveyed in forty fixed quadrats, transects, or tidepools in each of three areas along the Monument's western shore. Reconnaissance observations also were recorded for each area.

During both April and June post-spill surveys, the intertidal zone at the Cabrillo National Monument appeared fairly typical of the ecosystem as monitored during the two years prior to the spill. There was no evidence of catastrophic impacts. Index species generally looked healthy. With relatively few exceptions, abundances for the index taxa were within typical ranges of variability. Where variations occurred, there were no consistent trends among the three survey areas that would suggest some impact gradient. Goose barnacles, rockweed, owl limpets, red algal turf, aggregating anemones, and sargassum weed showed fairly similar abundances among all six monitoring surveys. California mussels, surf grass, and feather boa kelp showed similar abundances between the Fall 1991 pre-spill survey and the two post-spill surveys, while displaying varying trends with reference to surveys before Fall 1991. Woolly sculpins, not monitored prior to the spill, were present in reasonable numbers in tidepools following the spill. The only consistent index species changes were that barnacles declined in post-spill surveys, coincident with increases in algal cover in the same fixed plots. Reconnaissance observations of other species, especially those known to be sensitive to sewage pollution revealed healthy-appearing populations. The only obvious post-spill changes were increased cover of ephemeral green algae (primarily *Ulva*) and brown diatom film on upper intertidal rocks, increased silty-sand abundance in red algal turf mats, and the presence of a light brown scum that floated ashore with the rising tide. Floating or suspended particulates from the dumping of quarry rock onto new sewer pipe segments may have contributed to onshore sediment loads. However, the most probable impact from the massive two-month-long sewage spill was the addition of dissolved organic materials to the Cabrillo National Monument intertidal ecosystem. This likely produced the bloom of ephemeral plants observed on upper intertidal rocks. Some invertebrates, primarily barnacles, experienced overgrowth by the ephemeral green algae and diatom film. Possible low-level or long-term impacts from the spill could not be assessed in this study.

## INTRODUCTION

Sewage from San Diego is processed at the city's Wastewater Treatment plant located on the outer coast of the southern end of Point Loma. Treated sewage, from which approximately 80% of the solids have been removed, is pumped via pipeline 2.2 mi offshore to an outfall terminus in 220 ft of water. The effluent is not chlorinated. On February 2, 1992 a catastrophic rupture occurred in the undersea pipeline 0.6 mi offshore in 35 ft of water, releasing approximately 180 million gallons of sewage effluent per day. The spill continued for two months until pipeline repair work could be completed. During this time, bacteriological monitoring indicated that contaminated water was reaching the western intertidal shores of Point Loma. The direction and extent of the sewage plume varied with wind and sea current conditions. Human health concerns resulted in a quarantine (closure) of the beaches along Point Loma until the break was repaired and bacteria counts returned to safe levels. Repairs were accomplished by utilizing barges, cranes, and other equipment to remove damaged sections of pipe, to recondition the seabed, to lay new pipe sections, and to stabilize the pipeline with quarry rocks. On April 4, the last pipe segment was connected, thus ending the 63 day spill. Quarantines were lifted a few days later. Pipeline stabilization with rock and gravel dropped from above continued after the spill ended.

The Cabrillo National Monument (CABR) is located at the southern end of Point Loma, just south of the Wastewater Treatment Plant. The Monument includes approximately 0.6 mi of exposed rocky shores which are open to public visitation. The National Park Service's (NPS) long-term management goal for the CABR coast is to provide visitor access to a healthy, natural intertidal ecosystem. Tidepools and associated intertidal habitats within the Monument are among the most pristine and accessible in San Diego County, hosting diverse assemblages of plants and animals (Stewart and Meyers 1980, Stewart 1982). However, they do show effects from visitation and surrounding urban activities (Zedler 1978, Davis and Engle 1991). In Spring 1990 the NPS established a long-term intertidal monitoring program at CABR in order to detect resource degradation, to mitigate visitor impacts, and to restore natural resource conditions (Richards and Davis 1988, Davis and Engle, in prep.). Since then, key plants and animals have been surveyed at three sites within the Monument each Spring and Fall (Davis and Engle 1991).

The February 2, 1992 sewage pipe rupture occurred less than one mile from the nearest Cabrillo National Monument tidepools. Bacteriological monitoring stations documented that varying amounts of sewage bathed CABR intertidal habitats throughout the two-month spill, especially when the wind was onshore from the northwest. There may have been a gradient of sewage contact from the portion of CABR closest to the pipeline to the southernmost shore off the Point Loma Lighthouse. The entire National Monument shore was closed to public visitation for the duration of the spill.

Concerns regarding possible affects from the extensive sewage spill on intertidal life at the Cabrillo National Monument led to cooperative studies by the National Park Service and the San Diego Water Utilities Department. Four pre-spill seasonal surveys (Spring and Fall in 1990 and 1991) from the NPS long-term monitoring program at CABR provided baseline data for key intertidal organisms. The next NPS seasonal survey (Spring 1992) took place during April 11-13, just one week after cessation of the sewage spill. This survey documented the status of monitored organisms immediately following the lengthy spill. The Water Utilities Department then funded an additional follow-up survey (this study) utilizing the same methodology to assess important plant, invertebrate, and fish populations two months after the end of the spill. This survey, which took place on June 2-5, 1992, has provided comparable data to assist in determining whether rocky intertidal impacts (either immediate or delayed) have occurred, the type and extent of possible impacts, and if recovery from such impacts is expected to be rapid or prolonged.

Assessing possible impacts to rocky intertidal resources at the Cabrillo National Monument from the sewage spill is not an easy task. The National Park Service monitoring program was designed to be cost-effective and long-term; therefore, it does not provide extensive surveys of species or habitats. Detailed comparisons are limited to the particular taxa and permanent plots chosen. The resulting data are not necessarily representative of the entire intertidal community. Possible low-level or long-term impacts from the spill could not be assessed in this study. Other natural and human-related phenomena influenced this dynamic ecosystem during the same time period as the spill. A developing El Nino caused higher than normal sea temperatures and sea levels. Winter storms resulted in heavy surf and runoff of freshwater and sediments from the land. Untreated overflow sewage released from Tijuana may have reached Point Loma shores. Also, contaminated shores were closed to the public during the spill, thus extensive visitor use of the CABR rocky intertidal (with its own concomitant impacts) was curtailed.

This report presents the results of the June 2-5, 1992 post-spill intertidal survey at the Cabrillo National Monument. The information provided in the preliminary Data Report is included in this Final Report. Survey data and general observations are compared with those from the immediate post-spill National Park Service survey and the four pre-spill NPS surveys in a descriptive manner using summary tables and figures. Results of these comparisons are discussed with respect to possible impacts from the sewage spill and to various influences from other coincident phenomena.

## METHODS

The survey sites, species, and techniques employed for this June 1992 post-spill survey were exactly the same as for all previous National Park Service seasonal surveys, with the following few exceptions. Shore birds and people were not surveyed in June. A tidepool fish (woolly sculpin) was surveyed only during the April and June 1992 monitoring. Also, during these two post-spill surveys, reconnaissance observations, including photographs and videotape with commentary, were used to document the general condition of intertidal assemblages at each site. The rationale and detailed description of all survey methods are provided in reports by Davis and Engle (1991, and in prep.). Survey sites, index taxa, and monitoring techniques are described in summary fashion below.

### Survey Sites

Public access to the Cabrillo National Monument's intertidal zone is largely restricted to a single point on the western coast of Point Loma, approximately 0.5 mi north of the peninsula (Fig. 1). This situation creates a gradient of use, decreasing with distance from the access point. Since the National Park Service monitoring was designed primarily to evaluate visitor impacts, the Monument's outer coast intertidal zone was stratified into three areas of use, each encompassing roughly 0.2 mi of shoreline (Fig. 1). Area I, closest to the access point, receives the highest visitation. Also, it is nearest to the sewage pipe rupture site (0.9 mi). Area II, south of Grunion Beach to the Radio Tower, is 1.1 mi from the spill site. Area III, at the southwestern tip of Point Loma, is 1.3 mi from the broken pipe. At each of the three areas within CABR, the same index taxa were surveyed using identical techniques.

### Index Taxa

Typically, limited resources for long-term intertidal studies require that certain index taxa (species or higher taxonomic categories) be targeted for monitoring within fixed plots. Information about the population dynamics of a representative group of taxa can provide a reasonably accurate index of biological resource conditions. Criteria used to select index taxa include the following:

- Ecological importance: species that are dominant, abundant, or important in structuring intertidal communities (see Ricketts et al. 1985, Foster et al. 1988).
- Intertidal zonation: species characteristic of discrete intertidal heights.
- Impact indicator: species that are sensitive to various types of human impacts, especially if they are slow-growing or long-lived.
- Monitoring practicality: species that are readily identifiable, conspicuous, sessile or sedentary, and located high enough in the intertidal to permit sufficient time to sample.

The 14 NPS index taxa surveyed in June 1992 were goose barnacles (*Pollicipes polymerus*), thatched barnacles (*Tetraclita rubescens*), white acorn barnacles (*Chthamalus* spp.), rockweed (*Pelvetia fastigiata*), California mussels (*Mytilus californianus*), owl limpets (*Lottia gigantea*), woolly sculpins (*Clinocottus analis*), red algal turf (*Corallina* spp. et al.), aggregating anemones (*Anthopleura elegantissima*), surf grass (*Phyllospadix* spp.), sargassum weed (*Sargassum muticum*), feather boa kelp (*Egregia menziesii*), ochre seastars (*Pisaster ochraceus*), and black abalone (*Haliotis cracherodii*). Additional "taxa" scored in some plots included other plants, other animals, other biota, tar, and bare substrate.

#### Survey Techniques

The 14 index taxa within each of the three visitor use areas in CABR were surveyed within fixed quadrats, transects, and tidepools. Except for the tidepools, these "permanent" plots were originally established in Spring 1990 in a stratified random fashion to represent the range of tidal and biologic zones in locations typical of each taxon, subject to physical constraints of quadrat or transect dimensions. Plot sizes and survey techniques vary depending on the nature of the index taxa. Table 1 summarizes the sampling technique for each taxon. These survey techniques are summarized below.

#### Band-Transects

The abundance and distribution of goose barnacles (*Pollicipes polymerus*) were recorded in three band transects (1 m x 10 m) located on cliff faces or rip-rap at the base of the cliffs in each visitor use area. The dimensions of each clump of *Pollicipes* within 0.5 m of the transect line were recorded, and the presence of small (< 1 cm), medium-sized (1-3 cm), and large (> 3 cm) barnacles in each clump was noted.

#### Photogrammetric plots

Abundance and distribution of California mussels, *Mytilus californianus*, the barnacles, *Tetraclita rubescens* and *Chthamalus* spp., and rockweed, *Pelvetia fastigiata*, were measured from photographs made of 50 cm x 75 cm plots located on boulders. Fifteen plots were established and sampled in each of the three visitor use areas: five each representing suitable mussel, rockweed, and barnacle habitats. Photographs were made using a fixed quadrat camera frame with stereo mounted strobes and color slide film. Slides were projected on a life-sized grid of 100 uniformly distributed points. The number of points occupied by mussels, barnacles, rockweed, tar, miscellaneous plants, miscellaneous animals, and bare rock on each photograph were recorded to determine percent cover of each taxon.

#### Circular Plots

Owl limpet, *Lottia gigantea*, abundance and size frequency distributions were determined in six 1.0 m radius circular plots in each public use area: three plots were established on boulders and three on cliff faces or bedrock platforms. The numbers and sizes (maximum length in millimeters) of *Lottia gigantea* within 1.0 m of the bolts were recorded.

### Tidepool Fish Censuses

Woolly sculpin (*Clinocottus analis*) abundances in middle intertidal pools were censused in ten relatively discrete tidepools in each public use area. Since these cryptic fishes were difficult to count accurately, the number of sculpins observed in each pool was scored in four categories: none (0), rare (1), common (2-5), abundant (> 5). These censuses were conducted for the same pools during the April and June 1992 post-spill surveys only

### Line-Transects

Three strata of flat surfaces were sampled with replicate 10 meter-long line-intercept transects. Six transects were established in each visitor use area, two each at three elevations in the middle to low tidal zones, as characterized by distributions of red algal turf, surf grass (*Phyllospadix* spp.), and feather boa kelp (*Egregia menziesii*). The abundance and distribution of these three taxa, *Sargassum muticum*, *Anthopleura elegantissima*, other biotic cover, tar, and bare substrata were recorded as distances along the transects to the nearest centimeter.

### Timed Searches

Historically, black abalone, *Haliotis cracherodii*, and ochre stars, *Pisaster ochraceus*, were important components of the monument's intertidal system (Zedler 1978). Nevertheless, none were found during intensive searches of the entire study area in January and February, 1990 when monitoring techniques were being designed. Fixed-plot sampling could not be used for these species because of their low abundance, and instead timed searches (30 person-minutes) were conducted in each visitor use area for these two species during routine monitoring.

## RESULTS

A total of 120 fixed plots, transects, and tidepools were surveyed during June 2-5, 1992, 40 in each of the three public use areas of the Cabrillo National Monument (Table 1, Fig. 1). Early morning low tides ranged from -0.8 ft to -1.6 ft during the four-day survey period. Weather conditions were excellent, with foggy skies, light breezes, and calm seas. All of the survey work was completed successfully. The results of this survey as well as comparisons with previous surveys are provided for each index taxon sampled by the various survey techniques, followed by reconnaissance observations for all three intertidal areas.

### Band-Transects

Results of the goose barnacle surveys are presented in Tables 2-6 and Figures 2-4. Barnacle clumps in all transects appeared healthy and occurred in typical configurations. Areal coverage of goose barnacle clumps and mean clump size statistics for the nine transects in June generally were similar to those in April, especially when considering the variability inherent in defining and measuring irregular clumps (Table 3, Fig. 2A & B). Barnacle coverage and sizes during both post-spill surveys compare favorably with those of most pre-spill surveys. The unusually high values for Area III in Fall 1990 are likely artifacts due to inexperienced surveyors. The total number of clumps in Area I and II transects are higher in pre-spill surveys, while Area III shows no difference (Table 3, Fig. 3A). This is mostly due to greater numbers of small clumps ( $\leq 5 \text{ cm}^2$ ) recorded during April and June 1992, which likely reflects recruitment occurring since Fall 1991 (Tables 3-4, Figs. 3B & 4). Area III transects are located on boulder rip-rap, which has fewer crevices for recruits to attach to than the layered sedimentary bedrock cliffs of Areas I and II.

Typical goose barnacle clumps contain high proportions of small ( $< 1 \text{ cm}$ ) and medium-sized (1-3 cm) individuals, with fewer large ( $> 3 \text{ cm}$ ) individuals (Tables 5-6). Although observer estimates of barnacle size varied somewhat, there is a noticeable decline in the proportion of large individuals for the two post-spill surveys. Clumps  $\leq 5 \text{ cm}^2$  usually consist of recently-settled barnacles which are only small to medium in size. Thus the greater numbers of small clumps observed in April and June 1992 resulted in lower proportions of large individuals per clump for these surveys.

### Photogrammetric Plots

The abundance and distribution of acorn and thatched barnacles, rockweed, California mussels, other plants and animals, and bare rock recorded in 45 photoplots are reported in Tables 7-8 and Figures 5-6. The overall appearance of the plots was similar in June compared to April. Barnacle and mussel plots in all areas looked a bit greener in June due to slightly increased abundance of a thin layer of ephemeral green algae and diatoms. Of all the photoplot species, barnacles were the most difficult to score from photographs due to their small size and lack of contrast with the rock surface. Coverage of acorn and thatched barnacles (combined data) generally were

within the typical range of variation in both June and April 1992 compared to the four pre-spill surveys (Table 8, Fig. 5A). However, there was a trend (most evident in Area II) showing a decline in barnacle cover from Fall 1991 to Spring 1992, followed by a partial increase in June 1992. When the two barnacle species are considered separately, acorn barnacle cover dropped by 75-88% in Areas I and II in April, while thatched barnacles declined by 50-67% in Areas II and III (Table 8). Thatched barnacle cover remained low in June 1992, but acorn barnacle cover returned to typical levels. Low measured barnacle abundances in April coincided with high cover of "other plants" in April 1992, including ephemeral algae which covered some barnacles (Fig. 5B).

Rockweed (*Pelvetia fastigiata*) appeared healthy in both post-spill surveys. Plot coverage for all areas throughout all pre- and post-spill monitoring varied only from 59% to 86% (Table 8, Fig. 6A). This is remarkable considering that there is some variability in how the plant drapes over the rock after each high tide. Mussels are sparse at Cabrillo National Monument. Those present are old, relatively large individuals. Mussel cover in the three areas in June 1992 ranged from 7% to 26%, no different from that in Spring 1992 or the pre-spill survey in Fall 1991 (Table 8, Fig. 6B). Mussels clearly have declined since the National Park Service monitoring began in Spring 1990, especially in Area II where cover has dropped from 55% to 7%. This trend represents part of a long-term decline in mussel abundance at CABR, since mussels obviously dominated large boulders in the mid-1970's (Zedler 1976).

#### Circular Plots

Results of the owl limpet surveys are presented in Tables 9-12 and Figures 7-8. Owl limpets in the Monument approach the maximum size for the species (90 mm; Morris et al. 1980) and are relatively abundant. They maintain grazing territories (Stimson 1973), some of which were especially conspicuous in Areas I and II during the post-spill surveys due to their lack of ephemeral green algae which was common on surrounding rock surfaces. Overall, the appearance and distribution of limpets in the 18 circular plots at CABR appeared normal during both April and June 1992 surveys, with two exceptions. Fewer limpets were observed in plot #243, coincident with a large break-out of sedimentary rock located just above the plot (Tables 9-10). Pieces of rock, possibly dislodged by storm swells, may have tumbled through the plot, killing some limpets. Also, in June 1992, the largest limpet (78 mm) in plot #266 was found with the top of its shell broken shortly after a group of children wandered through the area. This individual was no longer present the next day.

The total number of owl limpets counted per area during all six surveys varied from 161 to 260 individuals (Table 11, Fig. 7A). Much of this variation correlates directly with the experience of the observer in locating limpets hidden in crevices. The total number of limpets surveyed in the various areas during post-spill surveys was within typical ranges of abundance except in Area III, where the lowest number of limpets in Spring 1992 (counted by less experienced observers) was followed by the highest number in June (scored by more experienced observers). Since owl limpets are slow-growing and sedentary, and the numerical trends are not consistent among the

three areas, it is unlikely that differences among surveys reflect major population changes.

Overall, the average size of owl limpets in the three areas varied only from 43 mm to 53 mm. throughout all six surveys (Table 11, Fig. 7B). Much of this variation is probably due to differences in the ability of observers to differentiate small owl limpets from other limpet species. Mean sizes were especially similar between the Fall 1991 survey and the two post-spill surveys. Length-frequency data also show fairly consistent patterns among the six survey periods (Table 12, Fig. 8). In all three areas, more small limpets were recorded during Fall 1990 and Spring 1991 surveys than at any other time. This may indicate a recruitment pulse. Data summarized for boulder versus cliff habitats show no major trends in either number or size of limpets among all the surveys (Table 11). The average size of owl limpets on cliff habitats is slightly smaller than those on boulders.

#### Tidepool Fish Censuses

Relative abundance data for woolly sculpins (*Clinocottus analis*) in tidepools are reported in Tables 13-14 and Figure 9. Tidepool fish counts were not conducted during any pre-spill surveys. Sculpins were found in the majority of the 30 pools examined in both post-spill surveys (Table 14, Fig. 9). They were more common in all three areas in June (93% of pools contained one or more sculpins) compared to April (53% occupied). Variability in locating these small cryptic fishes in craggy, algae-lined pools is not unexpected. Also, the tides were lower in June and the survey pools smaller. It is likely that in June the sculpins were more concentrated in the draining pools and therefore easier to find.

#### Line-Transects

The abundance and distribution of feather boa kelp, sargassum weed, red algal turf, surf grass, aggregating anemones, other biota, and bare rock recorded in 18 line-intercept transects are presented in Tables 15-16 and Figures 10-11. The major dominants, red algal turf (in upper-level transects), surf grass (in mid-level transects), and boa kelp (in lower-level transects) all appeared conspicuous and healthy throughout the Cabrillo National Monument. The cover of red algal turf, which includes a mixture of small plants dominated by *Corallina* spp. (Stewart 1982, 1989), was remarkably consistent throughout the six surveys in all areas, ranging from 71% to 94% in the upper-level transects (Table 16, Fig. 10A). There were no major pre-spill versus post-spill differences in cover, although Area III cover increased slightly. Turf cover also made up 6-26% of mid-level transects and 11-66% of lower-level transects, with the amount of turf typically varying inversely with surf grass or boa kelp cover. Since only the top layer of cover was scored, turf would not be recorded whenever overlying plants occurred.

Percent cover of surf grass in the mid-level transects ranged from 40% to 79% in the three areas over all surveys (Table 16, Fig. 11A). Spring values tended to be lower than Fall values. Post-spill surveys showed slight increases in surf grass cover in

all areas, except for Area III in Spring 1992. Surf grass cover also generally increased in lower-level transects since the National Park Service monitoring began (Table 16, Fig. 11B). Surf grass cover in Area II reached a peak of 47% in April 1992, then dropped to 29% in June. Overall, surf grass may have benefited some by cooler water conditions that prevailed during Summer 1991.

Feather boa kelp cover in the lower-level transects during both post-spill surveys was within the range of variation recorded during the pre-spill Fall 1991 survey (Table 16, Fig. 10B). Post-spill values for boa kelp cover in Area I declined slightly in April and June 1992 while Area II and III values increased. During Fall 1991 and Spring 1992, the lower-level transects were periodically awash during the scoring, a factor that likely increased sample variability during these surveys. For all three areas, there is a trend of decreasing boa kelp cover from Spring 1990 to Spring 1991, followed by a return to the original levels by June 1992. This pattern may have resulted from the unusually warm temperatures during Summer 1990 (detrimental), followed by especially cool temperatures in Summer 1991 (beneficial).

Aggregating anemones covered a small portion of the upper-level transects in all three areas (Table 16). Anemone cover was similar (1-2%) for all pre- and post-spill surveys. Sargassum weed was occasionally present along all transect levels, but primarily in mid- and low-level transects of Areas II and II (Table 16). Cover ranged from 0% to 14%, with generally higher cover during spring surveys when reproductive fronds are present. Healthy-appearing sargassum weed was recorded on both post-spill surveys.

#### Timed Searches

Black abalone and ochre seastars used to occur at the Cabrillo National Monument (Zedler 1978). Timed reconnaissance searches of approximately 30 person-minutes per area for these two species have not revealed a single live specimen during any of the six pre- or post-spill surveys (Tables 17-18). Other species of abalone or seastar were rarely recorded, except for juvenile bat stars which were located in moderate numbers at times when rocks were overturned. Bat stars were found during both post-spill surveys, especially in Areas II and III.

#### Reconnaissance Observations

In addition to the quantitative data from fixed plots, overview reconnaissance of the entire Cabrillo National Monument open coast intertidal zone (consisting of observations, photographs, and video documentation) provided further perspective on pre-spill versus post-spill intertidal ecosystem comparisons. In general, the intertidal region at CABR during the April and June post-spill surveys looked fairly typical of the system that was monitored in the two years prior to the sewage spill. There was no evidence of catastrophic changes in any of the index species. Some non-index species and minor habitat changes were noted during the post-spill surveys. Most notable during the April survey was an obvious increase in the cover of ephemeral green algae (primarily *Ulva* and *Enteromorpha* types) and brown slime (apparently diatoms, but

may also include blue-green algae) on upper intertidal rock surfaces. The green algae consisted of tiny blades and filaments forming a thin turf. This turf was more common in Areas I and II than in Area III, perhaps because Area III has less extent of upper intertidal zone. Even where present, it was patchy, being more common on partially shaded surfaces. It was not as obvious in middle and lower intertidal zones, except where the occasional overturned rock provided a fresh surface. Some owl limpet territories had varying degrees of ephemeral green algae cover, which was obviously being grazed by the limpets. Some of the barnacle photoplots contained this cover, which, along with a thicker brown turf (*Gelidium* sp.), covered over some of the barnacles. The brown diatom slime was more widespread. It formed a thin film which made upper intertidal rock surfaces extremely slippery. Green and brown ephemeral plant cover was especially common on some of the areas most-heavily walked by visitors, where essentially bare rock had previously been present. The CABR intertidal region was closed to visitors throughout the duration of the spill. By the last day of the April survey, after hundreds of weekend visitors had explored the reopened tidepools, the softer green algae cover was greatly reduced in the most-trampled paths.

The ephemeral green algae and brown slime cover was still common during the June survey, but appeared slightly less common than in April. It was definitely not as common on the sunniest high intertidal rocks, especially on heavily trampled paths, but was still obvious in damp, shady areas. There now appeared to be more small green blades on some goose barnacle clumps, on some acorn barnacles, and on some surf grass and sargassum plants. Middle and upper intertidal damp rocks were still slippery due to the brown slime, but this cover did not appear to be as abundant as in April. Ephemeral green algae and brown slime diatom coatings were observed on pre-spill surveys as well, but they were not as common as in April and June 1992.

Another change noted in April and to a lesser extent in June was that the red algae turf appeared to be more heavily silted in some areas. Often, it appeared very short, but when probed it was actually an inch or two deep, embedded in a matrix of silty sand. The sand cover on the inner beach in Area I was not unusually high or low. Also, in all three Areas, there was a light brown, flocculent scum that floated into inshore tidepools as the incoming tide apparently lifted these light particulates off the reef flats. The origin of this foamy scum (which was also observed in June) is unknown. It is also not known if this material was present during any of the pre-spill surveys. During the April surveys, large plumes of turbid water could be seen drifting downwind (southeast) of the offshore barges which were dropping rock material to stabilize the repaired sewer pipe.

The condition of conspicuous plants and animals throughout the Cabrillo National Monument was noted during the April and June reconnaissance surveys. The typical complement of species were observed to be present in all areas. There were no obvious dead or dying animals or deteriorating plants, with a few minor exceptions (e.g., one dead loon was seen in Area III). Sea hares, turban snails, and hermit crabs were common, as usual. Hopkins rose nudibranchs (*Hopkinsia rosacea*) were notably

abundant. Surf grass (which is known to be sensitive to some environmental impacts (Foster et al. 1988)) appeared a healthy bright green, with no deterioration evident. The plants were not heavily coated with diatoms or other epiphytes. Many surf grass plants had some of the typical small red epiphytic algae (*Smithora naidum*) on older blades, as well as scattered coralline crusts (*Melobesia mediocris*). Surf grass in the quiet-water pools of Area III carried more epiphytes. Sargassum weed appeared healthy in April, while in June the typical deterioration of post-reproductive fronds was observed. Adult boa kelp also was healthy in April and June. Young plants were notably common, some having settled unusually high up in the middle intertidal zone, just below bands of rockweed. These uppermost juveniles were not as healthy, with deterioration evident in June. Other juvenile boa kelp located in the low intertidal zone (where adult plants thrive) remained healthy. Also in June, large amounts of drift giant kelp were washed ashore in the cove between Areas I and II. Instead of whole plants, most of this kelp was in small fragments.

## DISCUSSION

Municipal wastewater discharges are a major source of marine pollution. Continual release of large volumes of complex residential, commercial, and industrial wastes into coastal marine environments via a single outfall pipe is known to disturb subtidal and intertidal ecosystems (see Foster and Schiel 1985, and Foster et al. 1988 for reviews). Sewage discharge pipes generally are extended as far offshore as feasible in order to minimize nearshore impacts. When San Diego's Point Loma sewage outfall pipe ruptured, release of approximately 180 million gallons per day of treated sewage occurred only 0.6 mi offshore instead of 2.2 mi out to sea. This nearshore spill, which continued for two months, created a plume of municipal wastes that reached the western shores of the Cabrillo National Monument in varying amounts, depending on the direction and intensity of wind and water currents. Components of the treated sewage that could impact marine life include fresh water, suspended solids, toxic chemicals, nutrient-rich organic compounds, and various pathogens.

Littler and Murray (1975) monitored the effects of a small outfall at San Clemente Island that discharged untreated sewage directly onto the intertidal zone. Ecological changes in the local intertidal community included reduced species diversity and community complexity. The reduced complexity was due primarily to the absence of surf grass, feather boa kelp, and two other brown algae (*Halidrys dioica* and *Sargassum agardhianum*). These species were replaced by rapidly growing, opportunistic colonizers ("weed" species). Impacted habitats compared to unaffected areas had less plant cover and more invertebrates in the lower intertidal, but more plants and fewer invertebrates in the upper intertidal. Other studies on the effects of sewage discharges reported loss of various furoid brown algae, including the rockweed *Pelvetia* (Munda 1974, Thom 1983).

Table 19 summarizes results of the June 2-5, 1992 intertidal survey of index taxa for three different areas at the Cabrillo National Monument. Similar summary data for the April 1992 (S92) immediate post-spill National Park Service survey and the four pre-spill NPS surveys are provided for comparison. In general, abundances for nearly all of these index taxa during the April and June 1992 post-spill surveys appear to be within typical ranges of variability, especially when considering some inherent variability among surveyors in collecting the data, and that coincident phenomena also were influencing the system to some unknown extent. These concurrent events include the following: 1) higher than normal sea temperatures and sea levels caused by El Nino, 2) occasional heavy surf and runoff of fresh water and sediments from the land that occurred during a series of winter/spring storms, and 3) absence of visitor impacts (primarily trampling) during the two months that contaminated shores were closed to the public. Also, the June survey has no equivalent from previous years, thus seasonal factors might be involved in changes seen only in this survey.

There may have been a slight gradient of sewage influence over the three survey areas of CABB (Area I=0.9 mi, Area II=1.1 mi, Area III=1.3 mi from the spill site); however, there were no corresponding trends over the three areas for any of the monitored taxa, except perhaps the barnacles (Table 19). White acorn barnacle cover dropped in Areas I and II in April 1992 coincident with a major increase in other plants which likely covered the small barnacles. Area III did not show this immediate post-spill decline, although other plants increased in these plots as well. The gradient influence hypothesis is further weakened by the fact that thatched barnacles declined most in Areas II and III in the post-spill surveys. Declines in barnacle cover may not necessarily represent mortality. Barnacles may have fouling algae attached to their tests to such an extent that they cannot be discerned in the photographs.

When the data from all areas are combined, a summary view of all survey results is possible (Table 19). Overall, the only "taxa" that changed greatly in post-spill surveys were the barnacles and the bare substrate in line transects, both of which declined coincident with increases in algal cover. Interestingly, acorn barnacle cover returned to typical levels in June, indicating that temporary overgrowth by algae in April may have caused the immediate post-spill decline. Goose barnacles, rockweed, owl limpets, red algal turf, aggregating anemones, and sargassum weed showed fairly similar abundances among all six surveys. California mussels, bare rock in photo plots, surf grass, and boa kelp generally showed similar abundances between the Fall 1991 pre-spill survey and the two post-spill surveys (which likely rules out spill effects), while displaying broader trends of increasing (e.g., surf grass, boa kelp) or decreasing (e.g., mussels, bare rock) abundances with reference to surveys before Fall 1991. Woolly sculpins were sampled only in April and June 1992, so pre-spill numbers are not known. However, the tidepool fish surveys did show that these sculpins were present in reasonable numbers following the spill.

The reconnaissance observations during post-spill surveys indicated that there were no catastrophic changes in the Cabrillo National Monument intertidal ecosystem. Nearly all species observed looked healthy and occurred in typical numbers. Species known to be sensitive to sewage pollution (e.g., surf grass, feather boa kelp, rockweed, and *Halidrys*) were examined in more detail. All appeared healthy. The only obvious post-spill changes noted at CABB were increased cover of ephemeral green algae and brown diatom slime on upper intertidal rock surfaces, increased silty-sand abundance within red algal turf mats, and the presence of a light brown scum that floated inshore with the rising tide.

Ephemeral algae and diatoms, though not specifically monitored, also were present during pre-spill surveys, but were never as common as after the spill. Stewart (1982) found *Ulva* in the San Diego area to reach its maximum abundance during January-March. These ephemeral plants typically are rapidly-growing, opportunistic forms associated with disturbance (e.g., in areas scoured by sand or where swells overturn rocks). It is possible that this ephemeral plant bloom was natural, maybe a result of storm-related disturbances. However, ephemeral plants also thrive in areas

disturbed by pollutants, including intertidal regions impacted by sewage outfalls (Littler & Murray 1975). *Ulva*, in particular, uses ammonia as a nitrogen source and is quite tolerant of organic pollution (Dawson & Foster 1982). Therefore, since dissolved organic material was one of the most likely components to wash ashore from the sewage spill, it seems quite probable that the ephemeral algae bloom was caused (or at least enhanced) by the massive, two-month-long spill. One consequence of the bloom is that some barnacles were overgrown. This appears to be a relatively minor effect, since many barnacles apparently survived under the algae. Also, barnacles can recolonize fairly rapidly. A bloom like this typically is short-lived. The ephemeral plant cover seemed to be a bit less in June. The lack of visitors to the intertidal probably protected ephemerals in areas where people typically walk. Shortly after visitors returned, *Ulva* cover was reduced on these areas.

It is not known whether the heavily-sanded red algal turf or the light brown scum seen on the water surface during post-spill surveys have any connection with the sewage spill. Coralline turf mats form a matrix that commonly traps sediment. Stewart (1983) noted that red algal turf on San Diego shores can change from 100% *Corallina* to 100% sand mat (covering live *Corallina*) within 2-6 weeks. Clearly then, natural processes could have caused the sanded turf (e.g., via sediment runoff from land during rainstorms). The foamy brown scum was not noted on pre-spill surveys, but it too might be the result of a natural process that was not noticed before. Nevertheless, large plumes of turbid water could be seen offshore whenever barge loads of quarry rock were dropped over the newly-laid sewer pipe. It is possible that floating or suspended particulates from this operation drifted ashore. In any event, minimal impacts would be expected from the relatively small amounts of drifting scum observed, unless the material contained toxic substances.

Unexplained events such as the catastrophic break in San Diego's offshore wastewater pipe underscore the need for routine resource monitoring in special status marine environments. In this case, a practical monitoring program established by the National Park Service for the Cabrillo National Monument provided baseline information about ecologically important intertidal organisms. Pre-spill monitoring combined with timely post-spill surveys permitted reasonable evaluation of possible short-term spill impacts (possible long-term or low-level impacts from the spill were not assessed in this study). Fortunately in this case there were no discernible major impacts on populations of monitored species. The most probable impact was the addition of dissolved organic materials to the intertidal ecosystem during February and March 1992. This likely produced the bloom of ephemeral plants observed on upper intertidal rocks. Some invertebrates, primarily barnacles, experienced overgrowth by the ephemeral green algae and diatom film.

## ACKNOWLEDGMENTS

Special thanks to the U. S. National Park Service, especially Gary Davis, and the Cabrillo National Monument for providing field equipment and intertidal assistance in carrying out the June 1992 survey. Additional valuable help was provided by Robert Gladden, Constance Gramlich, and biologists from the Point Loma Wastewater Laboratory. Many others volunteered to help on the earlier NPS monitoring surveys. Gary Davis, Jessica Altstatt, and Brandon Cole assisted in the data analysis and report preparation. Patricia Vainik of the Point Loma Wastewater Laboratory initiated and coordinated this cooperative study involving the City of San Diego and the National Park Service. This project was funded by the Metropolitan Wastewater Division of the San Diego Water Utilities Department.

## LITERATURE CITED

- Davis, G. E., and J. M. Engle. 1991. Ecological condition and public use of the Cabrillo National Monument intertidal zone in 1990. U. S. National Park Service Cooperative Resources Studies Unit Technical Report No. 20. 33 p.
- Davis, G. E. and J. M. Engle. In Prep. A handbook for monitoring ecological conditions and public use in the intertidal zone of Cabrillo National Monument, San Diego, California. National Park Service, Ventura CA.
- Dawson, E. Y. and M. S. Foster. 1982. Seashore plants of California. Univ. of California Press, Berkeley, CA. 226 p.
- Foster, M. S. and D. R. Schiel. 1985. The ecology of giant kelp forests in California: a community profile. U. S. Fish Wildl. Serv. Biol. Rep. 85 (7.2). 152 p.
- Foster, M. S., A. P. Vogelaere, C. Harrold, J. S. Pearse, and A. B. Thum. 1988. Causes of spatial and temporal patterns in rocky intertidal communities of central and northern California. *Memoirs of the Calif. Acad. Sci.* No. 9. 45 p.
- Littler, M. M. and S. N. Murray. 1975. Impact of sewage on the distribution, abundance, and community structure of rocky intertidal macro-organisms. *Marine Biol.* 30: 277-291.
- Morris, R. H., D. P. Abbott and E. C. Haderlie. 1980. Intertidal invertebrates of California. Stanford Univ. Press., Stanford, CA. 690 p.
- Munda, I. 1974. Changes and succession in the benthic algal associations of slightly polluted habitats. *Rev. Int. Oceanogr. Med.* 34:37-52.
- Richards, D. V. and G. E. Davis. 1988. Rocky intertidal communities monitoring handbook, Channel Islands National Park, California. National Park Service, Ventura, CA 93001. 15 p.
- Ricketts, E. F., J. Calvin, and J. W. Hedgpeth, revised by D. W. Phillips. 1985. *Between pacific tides*, 5th Ed. Stanford Univ. Press, Stanford, CA. 652 p.
- Stewart, J. G. and B. Meyers. 1980. Assemblages of algae and invertebrates in southern California *Phyllospadix*-dominated intertidal habitats. *Aquatic Botany* 9: 73-94.
- Stewart, J. G. 1982. Anchor species and epiphytes in intertidal algal turf. *Pacific Sci.* 36(1): 45-59.

- Stewart, J. G. 1983. Fluctuations in the quantity of sediments trapped among algal thalli on intertidal rock platforms in southern California. *J. Exp. Mar. Biol. Ecol.* 73:205-211.
- Stewart, J. G. 1989. Establishment, persistence and dominance of *Corallina* (Rhodophyta) in algal turf. *J. Phycol.* 25:436-446.
- Stimson, 1973. The role of territory in the ecology of the intertidal limpet *Lottia gigantea* (Gray). *Ecology* 54: 1020-30.
- Thom, R. M. 1983. Spatial and temporal patterns of *Fucus distichus* ssp. *edentatus* (de la Pyl.) Pow. (Phaeophyceae: Fucales) in central Puget Sound. *Bot. Mar.* 26:471-486.
- Zedler, J. B. 1976. Ecological resource inventory of the Cabrillo National Monument intertidal zone. Biol. Dept. San Diego State Univ. Proj. Rpt. USDI, National Park Service. 69 p.
- Zedler, J. B. 1978. Public use effects in the Cabrillo National Monument Intertidal Zone. Biol. Dept. San Diego State University proj. rep. for U. S. Dept. Interior, National Park Service. 52 p.

**Table 1. Intertidal natural resources and monitoring techniques in Cabrillo National Monument, California.**

<u>Technique/Taxa</u>	<u>Dimensions</u>	<u>Number Per Area</u>	<u>Total Sample</u>
Band Transect	1 X 10 m	3	9
Goose Barnacle			
<i>Pollicipes polymerus</i>			
Photoplot	50 X 75 cm	15	45
Rockweed			
<i>Pelvetia fastigiata</i>			
California Mussel			
<i>Mytilus californianus</i>			
Pink Thatched Barnacle			
<i>Tetraclita rubescens</i>			
Acorn Barnacle			
<i>Chthamalus</i> spp.			
Other Biota			
Tar			
Bare Substrate			
Circular Plot	1.0 m radius	6	18
Owl Limpet			
<i>Lottia gigantea</i>			
Tidepool Fish Census	variable pool size	10	30
Line Transect	10 m (1.0 cm)	6	18
Boa Kelp			
<i>Egregia menziesii</i>			
Sargassum Weed			
<i>Sargassum muticum</i>			
Red Algal Turf			
<i>Corallina</i> spp. et al.			
Surf Grass			
<i>Phyllospadix</i> spp.			
Aggregating Anemone			
<i>Anthopleura elegantissima</i>			
Other Biota			
Tar			
Bare Substrate			
Timed Search	30 person-minutes	1	3
Black Abalone			
<i>Haliotis cracherodii</i>			
Ochre Starfish			
<i>Pisaster ochraceus</i>			

# JUNE 1992 GOOSE BARNACLE DATA FOR 9 BAND TRANSECTS

CLUMP NUM	CLUMP DIAMETERS (cm) IN 1 X 10 m BAND TRANSECTS								
	CABR AREA I			CABR AREA II			CABR AREA III		
	276	278	281	273	274	275	22	23	269
1	13	3	38	1	3	3	3	384	1728
2	3	1	56	1	30	1	20	861	52
3	3	24	1	3	28	20	144	7	415
4	3	45	10	1	3	24	3	306	231
5	160	119	20	1	30	20	148	36	3
6	144	13	1	8	33	18	3	78	8
7	1	154	88	16	3	60	255	491	308
8	1	60	54	1	21	28	20	255	80
9	7	403	13	2	10	1	336	133	3
10	1	98	1	12	252	1	3	7	4
11	3	7	8	8	6	1	123	150	7
12	7	4	6	20	2	1	177	531	36
13	1	1	13	2	12	1	182	2	42
14	1	28	1	1	64	1	20	2	7
15	1	3	152	15	1	1	6	20	99
16	1	7	6	3	3	1	8	6	16
17	1	38	1	18	260	2	3	7	39
18	1	3	1	8	1	1	15	79	3
19	3	1	2	48	1	1	64	4	234
20	1	7	4	3	1	1	74		231
21	1	1	1	3	2	1	910		1
22	20	48	82	1	1	1	108		1
23	101	21	248	1	1	8	3		3
24	246	50	21	6	3	224	3		210
25	1	3	178	1	1	1	3		452
26	13	20	3	1	1	24	13		
27	133	38	1	2	2	1	3		
28	7	32	3	3	14	204	7		
29	8	97	46	1	10	117	3		
30	3	56	80	3	1	60	4		
31	3	20	1	3	1	54	3		
32	3	12	13	7	1	27	3		
33	7	3	1	12	2	1	1		
34	13	10	1	1	2	1	3		
35	72	72	1	8	3	1	3		
36	13	6	1	6	5	30	3		
37	1	7	1	2	60	3	4		
38	7	64	290	560	2	2	3		
39	154	7	88	1	2	28	1		
40	470	18	12	10	1	2	1		
41	91	12	12	12	3	3	1		
42	3	20	15	18	3	6	6		
43	110	3	626	21	11	2	3		

# JUNE 1992 GOOSE BARNACLE DATA FOR 9 BAND TRANSECTS

CLUMP NUM	CLUMP DIAMETERS (cm) IN 1 X 10 m BAND TRANSECTS								
	CABR AREA I			CABR AREA II			CABR AREA III		
	276	278	281	273	274	275	22	23	269
44	80	13	28	252	1	1	16		
45	304	91	15	7	3	1	4		
46	635	3	122	6	8	3	13		
47	12	7	1	3	7	6	3		
48	1	13	1	3	1	1	7		
49	3	12	2	20	2	1	3		
50	7	10	3	8	2	120	3		
51	288	3	1	2	2	1	3		
52	497	15	3	3	3	1	3		
53	88	226	467	10	1	3	7		
54	221	30	2	130	1	2			
55	198	8	4	12	4	28			
56	84	3	1	20	3	28			
57	35	20	1	63	2	1			
58	35	2	2	45	5	3			
59	1	2	27	84	18	1			
60	6	2	2	8	4	6			
61	1	20	10	36	3	8			
62	1	3	3	10	1	2			
63	1	68	3	2	8	8			
64	4	6	4	15	3	2			
65	1	28	2	15	2	1			
66	1	130	1	84	2	4			
67	1	15	3	24	3	6			
68	3	3	12	2	208	2			
69	48	203	28	352	50	1			
70	3	7	15	1	13	1			
71	12	6	2	143	2	28			
72	35	3	1	10	1	12			
73	10	2	44	3	1				
74	28	1	10	39	1				
75	3	1	28	9	2				
76	1	1	28	32	1				
77	3	88	28	96	3				
78	8	1	20	3	95				
79	69	2	6	1	7				
80	1	218	8	15	1				
81	3	28	18	4	12				
82	3	3	72	4	20				
83	28	7	20	3	3				
84	20	3	60	14	2				
85	177	4	6	14	64				
86	480	7	52	24	1				

# JUNE 1992 GOOSE BARNACLE DATA FOR 9 BAND TRANSECTS

CLUMP NUM	CLUMP DIAMETERS (cm) IN 1 X 10 m BAND TRANSECTS								
	CABR AREA I			CABR AREA II			CABR AREA III		
	276	278	281	273	274	275	22	23	269
87	8	1	10	16	2				
88	48	60	3	14	79				
89	15	1	4	42	266				
90	7	56		3	1				
91	3	1		1	3				
92	8	3		10	1				
93	3	73		12	1				
94	87	7		36	1				
95	32	3		40	2				
96	7	42		8	1				
97	38	8		48	3				
98	24	20		203	1				
99	36	40		18	3				
100	148	4		24	3				
101	582	6		8	1				
102	36	28		2	64				
103	1	50		55	7				
104	3	7		3	24				
105	3	1		60	120				
106	7	1		4	20				
107	3	40		6	2				
108	20	5		54	1				
109	1	3		2	2				
110	6	1		90	1				
111	3	1		120	1				
112	20	21		24	1				
113	3	5		3	1				
114	3	1		1	1				
115	46	1		1	1				
116	182	1		4	1				
117	634	72		56	1				
118	122	61		6	1				
119	50	18		14	10				
120		4		6	8				
121		3			1				
122		1			1				
123		1			2				
124		107			40				
125		244			8				
126		54			1				
127		3			10				
128		300			27				
129		3			20				

# **JUNE 1992 GOOSE BARNACLE DATA FOR 9 BAND TRANSECTS**

CLUMP NUM	CLUMP DIAMETERS (cm) IN 1 X 10 m BAND TRANSECTS								
	CABR AREA I			CABR AREA II			CABR AREA III		
	276	278	281	273	274	275	22	23	269
130		7			1				
131		35			1				
132		42			2				
133		45			79				
134		2			105				
135		3			2				
136		2			1				
137		1			4				
138		1			6				
139		3			4				
140		4			3				
141		6			3				
142		18			1				
143		88			105				
144		8			1008				
145		70			1				
146		1			10				
147		7			30				
148		12							
149		88							
150		13							
151		15							
152		3							
153		1							
154		7							
155		15							
156		1							
SUM	7465	4817	3384	3480	3583	1270	2761	3359	4213
NUM	119	156	89	120	147	72	53	19	25
MIN	1	1	1	1	1	1	1	2	1
MAX	635	403	626	560	1008	224	910	861	1728
AVG	63	31	38	29	24	18	52	177	169
SD	130	57	93	69	93	40	139	239	352

# GOOSE BARNACLE SUMMARY DATA

SUM OF AREA COVERED (cm<sup>2</sup>), NUMBER OF BARNACLE CLUMPS, AND CLUMP SIZE (cm) STATISTICS FOR EACH OF 3 TRANSECTS PER AREA.  
DATA ARE PRESENTED FOR 6 SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF 3 SEPARATE AREAS OF THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I #276								AREA I #278								AREA I #281								AREA I ALL							
	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD
SPRING 90	7745	111	35	76	1	707	70	120	5080	130	39	91	1	491	39	69	3306	71	19	52	1	392	47	86	16131	312	93	219	1	707	52	94
FALL 90	8211	68	5	63	1	900	121	173	4599	60	2	58	2	525	77	108	2806	59	12	47	1	589	48	95	15615	187	19	168	1	900	84	135
SPRING 91	6430	80	20	60	1	660	80	117	5190	110	29	81	1	452	47	70	2283	61	16	45	1	420	37	73	13903	231	65	186	1	660	55	90
FALL 91	7000	76	21	55	1	735	92	162	4464	84	20	64	1	600	53	86	2571	53	13	40	3	462	49	85	14035	213	54	159	1	735	66	120
SPRING 92	8620	120	41	79	1	882	72	145	3779	125	48	77	1	294	30	55	3116	90	44	46	1	527	35	81	15514	335	133	202	1	882	46	104
JUNE 92	7465	119	50	69	1	635	63	130	4817	156	62	94	1	403	31	57	3384	89	40	49	1	626	38	93	15666	364	152	212	1	635	43	96

DATE	AREA II #273								AREA II #274								AREA II #275								AREA II ALL							
	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD
SPRING 90	2130	53	8	45	1	450	40	70	6568	37	3	34	3	1385	178	320	1816	48	12	36	1	319	38	75	10514	138	23	115	1	1385	76	186
FALL 90	2681	92	23	69	1	408	29	52	3640	51	12	39	1	962	71	138	1551	28	4	24	3	314	55	79	7872	171	39	132	1	962	46	92
SPRING 91	2677	141	77	64	1	408	19	47	3367	53	16	37	1	908	64	136	1393	40	16	24	1	227	35	59	7437	234	109	125	1	908	32	80
FALL 91	2009	95	36	59	1	319	21	42	2513	41	5	36	1	578	61	107	1506	34	11	23	1	304	44	72	6027	170	52	118	1	578	35	71
SPRING 92	3482	135	69	66	1	858	26	82	3873	59	23	36	1	1748	66	231	1745	44	18	26	1	315	40	73	9099	238	110	128	1	1748	38	134
JUNE 92	3480	120	47	73	1	560	29	69	3583	147	99	48	1	1008	24	93	1270	72	45	27	1	224	18	40	8333	339	191	148	1	1008	25	76

DATE	AREA III #22								AREA III #23								AREA III #269								AREA III ALL							
	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD	SUM	NUM	#S	#L	MIN	MAX	AVG	SD
SPRING 90	3185	47	18	29	1	714	68	149	1373	10	0	10	7	314	137	101	3220	16	0	16	7	616	201	216	7778	73	18	55	1	714	107	168
FALL 90	6908	15	0	15	8	3318	461	817	7360	8	0	8	314	2827	920	803	7431	13	0	13	8	2827	572	795	21699	36	0	36	8	3318	603	803
SPRING 91	2561	39	11	28	1	715	66	132	1977	18	4	14	1	296	110	107	4600	20	0	20	6	1810	230	407	9138	77	15	62	1	1810	119	240
FALL 91	2345	35	13	22	1	675	67	127	1499	13	4	9	1	375	115	141	3945	16	1	15	3	1590	247	414	7789	64	16	46	1	1590	122	243
SPRING 92	3406	60	25	35	1	1200	57	167	3142	14	3	11	1	988	224	358	5701	19	0	19	15	2576	300	585	12249	93	28	65	1	2576	132	337
JUNE 92	2761	53	29	24	1	910	52	139	3359	19	3	16	2	861	177	239	4213	25	7	18	1	1728	169	352	10333	97	39	58	1	1728	107	236

#S = # CLUMPS <= 5 CM<sup>2</sup> #L = # CLUMPS > 5 CM<sup>2</sup>

# SIZE DISTRIBUTION OF GOOSE BARNACLE CLUMPS IN 9 TRANSECTS DURING JUNE 1992

AREA CM^2	CABR AREA I TRANSECTS					CABR AREA II TRANSECTS					CABR AREA III TRANSECTS				
	276	278	281	ALL	%	273	274	275	ALL	%	22	23	269	ALL	%
5	50	62	40	152	42	47	99	45	191	56	29	3	7	39	40
10	16	24	10	50	14	22	14	7	43	13	6	4	3	13	13
15	7	12	9	28	8	13	5	1	19	6	3	0	0	3	3
20	4	9	4	17	5	8	4	3	15	4	4	1	1	6	6
25	1	3	1	5	1	5	2	2	9	3	0	0	0	0	0
30	2	5	6	13	4	0	5	7	12	4	0	0	0	0	0
35	4	2	0	6	2	1	1	0	2	1	0	0	0	0	0
40	3	4	1	8	2	4	1	0	5	1	0	1	2	3	3
45	0	4	1	5	1	2	0	0	2	1	0	0	1	1	1
50	4	3	1	8	2	2	1	0	3	1	0	0	0	0	0
55	0	1	2	3	1	2	0	1	3	1	0	0	1	1	1
60	0	4	2	6	2	2	1	2	5	1	0	0	0	0	0
65	0	2	0	2	1	1	3	0	4	1	1	0	0	1	1
70	1	2	0	3	1	0	0	0	0	0	0	0	0	0	0
75	1	3	1	5	1	0	0	0	0	0	1	0	0	1	1
80	1	0	1	2	1	0	2	0	2	1	0	2	1	3	3
85	1	0	1	2	1	2	0	0	2	1	0	0	0	0	0
90	2	3	2	7	2	1	0	0	1	0	0	0	0	0	0
95	1	1	0	2	1	0	1	0	1	0	0	0	0	0	0
100	0	2	0	2	1	1	0	0	1	0	0	0	1	1	1
105	1	0	0	1	0	0	2	0	2	1	0	0	0	0	0
110	1	1	0	2	1	0	0	0	0	0	1	0	0	1	1
115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	1	0	1	0	1	1	2	4	1	0	0	0	0	0
125	1	0	1	2	1	0	0	0	0	0	1	0	0	1	1
130	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0
135	1	0	0	1	0	0	0	0	0	0	0	1	0	1	1
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145	1	0	0	1	0	1	0	0	1	0	1	0	0	1	1
150	1	0	0	1	0	0	0	0	0	0	1	1	0	2	2
155	1	1	1	3	1	0	0	0	0	0	0	0	0	0	0
160	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180	1	0	1	2	1	0	0	0	0	0	1	0	0	1	1
185	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
205	0	1	0	1	0	1	0	1	2	1	0	0	0	0	0
210	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1
215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
225	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
230	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
250	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0
255	0	0	0	0	0	1	1	0	2	1	1	1	0	2	2
260	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

# SIZE DISTRIBUTION OF GOOSE BARNACLE CLUMPS IN 9 TRANSECTS DURING JUNE 1992

AREA CM ^ 2	CABR AREA I TRANSECTS					CABR AREA II TRANSECTS					CABR AREA III TRANSECTS				
	276	278	281	ALL	%	273	274	275	ALL	%	22	23	269	ALL	%
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0
295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
305	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2
315	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
335	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
355	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
385	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
395	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
405	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
415	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
435	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
455	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
465	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
470	1	0	1	2	1	0	0	0	0	0	0	0	0	0	0
475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
480	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
485	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
495	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
500	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
>500	3	0	1	4	1	1	1	0	2	1	1	2	1	4	4
# CLUMPS	119	156	89	364	100	120	147	72	339	100	53	19	25	97	100
AREA SUM	7465	4817	3384	15666		3480	3583	1270	8333		2761	3359	4213	10333	
MIN SIZE	1	1	1	1		1	1	1	1		1	2	1	1	
MAX SIZE	635	403	626	635		560	1008	224	1008		910	861	1728	1728	
MEAN	63	31	38	43		29	24	18	25		52	177	169	107	
ST DEV	130	57	93	96		69	93	40	76		139	239	352	236	
% COVER	7%	5%	3%	5%		3%	4%	1%	3%		3%	3%	4%	3%	

**SIZE DISTRIBUTION OF INDIVIDUAL GOOSE BARNACLES  
WITHIN CLUMPS IN 1 X 10 m BAND TRANSECTS**

JUNE 92 CABR AREA	BAND #	SMALL (<1cm)		MEDIUM (1-3cm)		LARGE (>3cm)		TOTAL # CLUMPS
		#	%	#	%	#	%	
I	276	111	93	82	69	59	50	119
	278	143	92	131	84	56	36	156
	281	73	82	82	92	16	18	89
	ALL	327	90	295	81	131	36	364
II	273	112	93	94	78	38	32	120
	274	125	85	88	60	37	25	147
	275	66	92	52	72	0	0	72
	ALL	303	89	234	69	75	22	339
III	22	34	64	42	79	16	30	53
	23	15	79	18	95	11	58	19
	269	18	72	19	76	15	60	25
	ALL	67	69	79	81	42	43	97
ALL AREAS		697	87	608	76	248	31	800

# GOOSE BARNACLE SIZE DISTRIBUTION SUMMARY TABLE

MEAN PERCENT OF GOOSE BARNACLE CLUMPS CONTAINING SMALL, MEDIUM, AND LARGE INDIVIDUALS FOR THREE 1 X 10 m TRANSECTS PER AREA.  
DATA ARE PRESENTED FOR SIX SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF THREE SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I			AREA II			AREA III			ALL AREAS		
	% ( $< 1\text{cm}$ )	% MEDIUM ( $1-3\text{cm}$ )	% LARGE ( $> 3\text{cm}$ )	% ( $< 1\text{cm}$ )	% MEDIUM ( $1-3\text{cm}$ )	% LARGE ( $> 3\text{cm}$ )	% ( $< 1\text{cm}$ )	% MEDIUM ( $1-3\text{cm}$ )	% LARGE ( $> 3\text{cm}$ )	% ( $< 1\text{cm}$ )	% MEDIUM ( $1-3\text{cm}$ )	% LARGE ( $> 3\text{cm}$ )
SPRING 90	82	95	59	75	93	71	67	81	71	78	93	64
FALL 90	68	92	81	80	94	50	86	86	56	75	92	65
SPRING 91	81	88	76	74	76	55	70	88	77	77	83	68
FALL 91	86	86	75	83	75	46	81	73	67	84	80	63
SPRING 92	85	78	16	78	82	15	63	91	34	79	81	18
JUNE 92	90	81	36	89	69	22	69	81	43	87	76	31

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

# **JUNE 1992 INTERTIDAL COVER DATA FOR 45 PHOTOPLOTS (50 X 75 cm)**

CABR AREA I	BARNACLES (% COVER)						ROCKWEED (% COVER)						MUSSELS (% COVER)					
PHOTOPLOT #	286	292	293	294	299	AVG	287	288	290	291	295	AVG	285	289	296	297	298	AVG
# POINTS SCORED	100	100	100	100	100		100	100	100	100	100		100	100	100	100	100	
ACORN BARNACLE	31	5	1	6	48	18	0	0	0	0	0	0	0	0	0	0	0	0
THATCHED BARNACLE	19	8	6	19	3	11	0	0	0	0	0	0	0	0	0	1	0	0
ROCKWEED	0	0	0	0	0	0	37	63	72	78	80	66	0	0	0	0	0	0
CALIFORNIA MUSSEL	0	0	0	2	0	0	0	0	0	0	0	0	5	3	21	10	9	10
OTHER PLANTS	6	45	18	43	2	23	21	31	13	21	19	21	20	66	18	20	17	28
OTHER ANIMALS	18	9	21	23	8	16	0	0	0	0	0	0	21	1	27	28	21	20
BARE SUBSTRATE	26	33	54	7	39	32	42	6	15	1	1	13	54	30	34	41	53	42

CABR AREA II	BARNACLES (% COVER)						ROCKWEED (% COVER)						MUSSELS (% COVER)					
PHOTOPLOT #	247	248	256	259	260	AVG	249	251	252	258	265	AVG	245	246	253	254	255	AVG
# POINTS SCORED	100	100	100	100	100		100	100	100	100	100		100	100	100	100	100	
ACORN BARNACLE	9	20	20	18	22	18	0	0	0	0	0	0	0	1	0	0	0	0
THATCHED BARNACLE	4	2	24	12	23	13	0	0	0	0	0	0	0	0	0	0	0	0
ROCKWEED	2	3	0	0	5	2	75	36	87	72	83	71	0	0	0	0	0	0
CALIFORNIA MUSSEL	0	0	13	0	0	3	0	0	0	0	0	0	9	23	0	0	2	7
OTHER PLANTS	20	4	19	7	17	13	13	63	9	12	4	20	61	55	92	63	90	72
OTHER ANIMALS	2	35	19	34	13	21	0	0	0	0	0	0	0	1	0	0	2	1
BARE SUBSTRATE	63	36	5	29	20	31	12	1	4	16	13	9	30	20	8	37	6	20

CABR AREA III	BARNACLES (% COVER)						ROCKWEED (% COVER)						MUSSELS (% COVER)					
PHOTOPLOT #	3	16	20	29	30	AVG	9	10	25	27	28	AVG	12	14	15	17	24	AVG
# POINTS SCORED	100	100	100	100	100		100	100	100	100	100		100	100	100	100	100	
ACORN BARNACLE	45	29	16	53	34	35	4	0	0	0	0	1	0	0	0	0	0	0
THATCHED BARNACLE	15	12	6	14	17	13	0	0	0	0	0	0	0	3	2	0	1	1
ROCKWEED	0	0	0	9	7	3	85	77	94	84	92	86	0	0	0	0	0	0
CALIFORNIA MUSSEL	0	0	0	0	0	0	0	0	0	0	0	0	23	25	26	33	21	26
OTHER PLANTS	7	7	0	3	12	6	3	20	6	6	8	9	23	15	10	15	30	19
OTHER ANIMALS	23	24	7	5	23	16	0	0	0	0	0	0	5	11	8	6	8	8
BARE SUBSTRATE	10	28	71	16	7	26	8	3	0	10	0	4	49	46	54	46	40	47

# PHOTOPLOT SPECIES SUMMARY DATA

MEAN PERCENT COVER FOR 7 TAXA IN FIVE 50 X 75 cm PHOTOPLOTS AT 3 INTERTIDAL ZONES (BARNACLE, ROCKWEED, MUSSEL) PER AREA. DATA ARE PRESENTED FOR 6 SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF 3 SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I BARNACLE							AREA I ROCKWEED							AREA I MUSSEL						
	AB	TB	RW	CM	OP	OA	BS	AB	TB	RW	CM	OP	OA	BS	AB	TB	RW	CM	OP	OA	BS
SPRING 90	2	20	0	0	15	20	43	0	0	59	0	20	2	19	0	2	0	16	29	17	37
FALL 90	13	16	0	1	27	6	38	0	0	62	0	23	0	15	0	1	0	9	38	16	36
SPRING 91	13	20	0	0	12	10	46	0	0	57	0	23	1	19	1	2	0	6	36	15	40
FALL 91	12	13	0	1	24	10	39	0	0	77	0	15	0	8	0	1	0	9	39	14	37
SPRING 92	3	19	0	1	55	4	18	2	0	60	0	25	0	12	0	0	0	7	44	14	35
JUNE 92	18	11	0	0	23	16	32	0	0	66	0	21	0	13	0	0	0	10	28	20	42

DATE	AREA II BARNACLE							AREA II ROCKWEED							AREA II MUSSEL						
	AB	TB	RW	CM	OP	OA	BS	AB	TB	RW	CM	OP	OA	BS	AB	TB	RW	CM	OP	OA	BS
SPRING 90	12	30	1	2	6	5	44	0	0	71	0	14	2	13	2	2	0	55	14	4	23
FALL 90	26	17	2	1	27	4	23	2	0	72	0	18	0	9	0	1	0	30	44	3	22
SPRING 91	28	26	1	1	5	2	37	2	0	68	0	19	0	11	2	1	0	20	39	4	34
FALL 91	23	21	1	1	27	11	16	1	0	75	0	19	0	6	1	1	0	18	52	3	24
SPRING 92	5	7	1	1	48	15	23	0	0	77	0	14	0	9	0	0	0	10	70	3	16
JUNE 92	18	13	2	3	13	21	31	0	0	71	0	20	0	9	0	0	0	7	72	1	20

DATE	AREA III BARNACLE							AREA III ROCKWEED							AREA III MUSSEL						
	AB	TB	RW	CM	OP	OA	BS	AB	TB	RW	CM	OP	OA	BS	AB	TB	RW	CM	OP	OA	BS
SPRING 90	13	22	1	0	9	10	45	2	0	84	0	3	6	5	5	5	0	47	0	4	38
FALL 90	26	29	2	0	10	3	30	3	1	74	0	5	11	6	8	4	0	34	10	4	40
SPRING 91	22	26	1	0	6	4	41	6	1	65	0	16	4	8	6	3	0	28	7	7	49
FALL 91	42	24	3	0	5	8	18	1	1	76	0	8	8	5	17	4	0	25	8	5	41
SPRING 92	34	12	1	0	31	1	22	2	0	71	0	21	0	6	24	1	0	21	12	3	39
JUNE 92	35	13	3	0	6	16	26	1	0	86	0	9	0	4	0	1	0	26	19	8	47

AB=ACORN BARNACLE TB=THATCHED BARNACLE RW=ROCKWEED

CM=CALIFORNIA MUSSEL OP=OTHER PLANTS OA=OTHER ANIMALS BS=BARE SUBSTRATE

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

# **JUNE 1992 OWL LIMPET DATA FOR 18 CIRCULAR PLOTS**

NUM	OWL LIMPET LENGTHS (mm) IN 2 m DIAMETER CIRCULAR PLOTS																	
	CABR AREA I						CABR AREA II						CABR AREA III					
	B282	B283	B284	C277	C279	C280	B239	B240	B241	C242	C243	C266	B11	B18	B19	B21	B26	C13
1	60	64	32	55	58	44	31	45	76	59	54	45	47	54	34	64	58	32
2	36	53	35	30	58	51	41	71	70	56	40	53	38	45	39	62	55	49
3	59	51	33	42	39	44	47	30	17	52	71	53	47	46	67	52	67	64
4	44	60	47	29	20	59	59	23	67	52	43	46	55	32	63	62	33	48
5	57	58	30	38	39	41	39	55	70	48	34	52	52	39	47	62	54	29
6	15	58	15	54	44	37	45	48	51	51	60	61	47	47	45	44	65	40
7	38	40	29	37	24	27	42	17	71	18	42	62	46	43	61	40	55	36
8	63	50	29	49	35	49	58	45	74	66	55	45	44	32	58	48	37	36
9	60	55	42	35	32	48	58	72	79	52	60	54	47	35	65	62	33	33
10	76	50	31	33	27	30	54	62	74	52	60	56	53	42	66	61	57	33
11	64	41	43	43	55	51	55	61	62	68	18	59	34	46	35	58	52	15
12	18	55	36	40	51	48	53	44	80	61	51	41	51	44	55	54	72	73
13	65	63	56	28	33	45	56	71	76	61	40	56	24	36	37	58	53	45
14	57	63	52	24	42	40	37	49	74	59	60	42	27	39	76	57	34	38
15	39		32	31	47	53	55	62	72	48		49	48	41	61	52	59	63
16	21		72	37	57	37	22	48	64	41		60	29	39	30	50	58	39
17	24		42	29	50	54	44	39	72	43		58	43	51	56	47	62	50
18	49		64	34	17	49	41	26	74	36		40	41	46	57	46	60	39
19	48		39	47	17	56	37	31	66			46	49	40	67	54	63	61
20	47		17	32	19	62	34	55	61			38	36	46	43	60	66	52
21	65		54	37	17	43	43	50	56			22	54	52	47	50		45
22	43		38	31	49	50	49	51	65			34	47	44	42	64		36
23	40		34	41	43	39	37	46	74			52	34	41	22	58		37
24	24		49	24	37	27	50		69			48	54	42	42	64		55
25	22		53	39	44	45	50		63			64	61	38	67	37		29
26	57		57	44	56	46			42			34	39	46	64	45		54
27	74		58	24	50	47			59			66	58	36	70	56		77
28	44		54	24	51	44			72			66	42	32	66			68
29	79		42	43	55	50			53			50	44	47	50			24
30	32		54	21	58	58			76			37	49	39	71			32
31	71		54	21	42	24			32			62	36	38	61			42
32	69		42	46	35	51			51			66	42	43	66			51
33	71		52	30								65	37	38	31			44
34	49		36	35								53	48	38				27
35	42		51	47								51	49	24				43
36	23		49	26								59	51	50				34
37	31		51	45								46	53	44				40
38			55	46								49	52	36				16

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

# **JUNE 1992 OWL LIMPET DATA FOR 18 CIRCULAR PLOTS**

OWL LIMPET LENGTHS (mm) IN 2 m DIAMETER CIRCULAR PLOTS																		
NUM	CABR AREA I						CABR AREA II						CABR AREA III					
	B282	B283	B284	C277	C279	C280	B239	B240	B241	C242	C243	C266	B11	B18	B19	B21	B26	C13
39			58	44								46	57	51				34
40			54	30								59	43	44				
41			44	43								39	52	47				
42			34	49								57	49	57				
43			54	36								51	48	43				
44			58	42								44	47	56				
45			63	30								52	62	54				
46			36	17								56	51	50				
47			54	51								63	48	46				
48			43	33								58	35	57				
49			23	37								58	48	52				
50			35	21								58	46	51				
51			37	51								54	42	43				
52			40	31								37	58	54				
53			40	34								38	53	50				
54			28	52								63	49	45				
55				40								41	54	35				
56				25								53		29				
57				44								53		49				
58				25								62		47				
59				35								47		45				
60				52								38		29				
61				35								37		53				
62				62								25		49				
63				37								40		40				
64												44		40				
65												27		53				
66												36		39				
67												25		30				
68												22		57				
69												44		30				
70												60		33				
71												53		47				
72														34				
73														63				
74														53				
75														37				
76														53				

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

# **JUNE 1992 OWL LIMPET DATA FOR 18 CIRCULAR PLOTS**

NUM	OWL LIMPET LENGTHS (mm) IN 2 m DIAMETER CIRCULAR PLOTS																	
	CABR AREA I						CABR AREA II						CABR AREA III					
	B282	B283	B284	C277	C279	C280	B239	B240	B241	C242	C243	C266	B11	B18	B19	B21	B26	C13
77													51					
78													40					
79													36					
80													50					
81													40					
82													46					
83													54					
84													43					
85													48					
86													32					
NUM	37	14	54	63	32	32	25	23	32	18	14	71	55	86	33	27	20	39
MIN	15	40	15	17	17	24	22	17	17	18	18	22	24	24	22	37	33	15
MAX	79	64	72	62	58	62	59	72	80	68	71	66	62	63	76	64	72	77
AVG	47	54	44	37	41	45	45	48	64	51	49	49	46	44	53	54	55	43
SD	19	8	12	10	13	9	10	15	14	12	14	11	8	8	14	8	12	14

B = BOULDER C = CLIFF

# OWL LIMPET SUMMARY DATA FOR INDIVIDUAL CIRCULAR PLOTS

NUMBER OF LIMPETS AND SHELL LENGTH (MM) STATISTICS FOR EACH OF SIX 1 M RADIUS PLOTS PER AREA.  
DATA ARE PRESENTED FOR SIX SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF THREE SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I #B282					AREA I #B283					AREA I #B284					AREA I #C277					AREA I #C279					AREA I #C280				
	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD
SPRING 90	27	33	81	56	14	25	39	68	50	7	54	22	70	46	10	16	36	59	50	7	28	37	58	47	6	54	28	64	47	8
FALL 90	40	23	85	58	15	19	26	64	50	10	59	19	67	42	13	42	19	63	37	10	22	22	61	47	12	60	18	64	45	12
SPRING 91	39	22	83	54	16	18	30	63	49	10	56	22	69	44	12	39	18	61	34	9	28	23	58	41	12	53	19	63	43	11
FALL 91	33	19	84	51	19	17	25	66	52	11	65	17	63	39	13	29	18	46	34	9	28	21	56	41	10	32	28	65	46	8
SPRING 92	32	26	79	52	16	15	38	66	54	8	60	21	70	42	12	38	20	50	35	8	35	18	56	42	11	33	29	59	45	8
JUNE 92	37	15	79	47	19	14	40	64	54	8	54	15	72	44	12	63	17	62	37	10	32	17	58	41	13	32	24	62	45	9

DATE	AREA II #B239					AREA II #B240					AREA II #B241					AREA II #C242					AREA II #C243					AREA II #C266				
	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD
SPRING 90	26	25	64	46	10	17	34	81	57	12	36	34	77	58	13	11	32	70	54	11	22	33	59	49	7	49	33	87	54	11
FALL 90	34	18	62	41	13	24	20	82	50	20	35	26	76	64	10	17	25	69	49	17	29	29	72	55	12	62	23	83	52	15
SPRING 91	34	20	61	39	13	23	25	78	49	17	35	28	76	62	12	14	29	70	46	14	28	24	66	45	13	76	19	81	44	15
FALL 91	24	30	58	45	9	22	19	77	50	15	37	20	78	62	15	21	27	67	48	12	32	24	71	54	12	70	19	80	46	13
SPRING 92	26	23	56	42	9	24	22	78	48	16	33	16	79	64	14	17	29	66	49	11	18	30	68	54	9	67	27	79	50	11
JUNE 92	25	22	59	45	10	23	17	72	48	15	32	17	80	64	14	18	18	68	51	12	14	18	71	49	14	71	22	66	49	11

DATE	AREA III #B11					AREA III #B18					AREA III #B19					AREA III #B21					AREA III #B26					AREA III #C13				
	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD	NUM	MIN	MAX	AVG	SD
SPRING 90	56	27	64	45	8	82	16	56	41	8	19	27	67	52	12	30	30	72	50	10	23	33	74	57	10	26	35	82	48	12
FALL 90	62	19	65	44	9	76	20	60	43	9	28	21	73	54	15	29	37	71	52	8	22	27	72	58	9	32	24	81	45	14
SPRING 91	60	20	64	44	9	78	20	60	40	10	27	26	73	54	15	28	27	66	50	9	23	28	71	56	10	31	24	80	45	13
FALL 91	55	23	66	44	8	71	23	64	43	9	30	32	74	55	13	21	41	61	53	5	20	30	71	56	9	22	26	78	45	11
SPRING 92	36	31	57	46	5	58	28	56	44	7	24	35	69	53	12	19	39	64	53	7	18	21	70	54	11	28	26	69	43	11
JUNE 92	55	24	62	46	8	86	24	63	44	8	33	22	76	53	14	27	37	64	54	8	20	33	72	55	12	39	15	77	43	14

# OWL LIMPET SUMMARY DATA FOR DIFFERENT HABITATS

NUMBER OF LIMPETS AND SHELL LENGTH (mm) STATISTICS FOR BOULDER AND CLIFF HABITATS.

DATA ARE PRESENTED FOR SIX SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF THREE SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT

DATE	AREA I BOULDER				AREA I CLIFF				AREA I ALL			
	NUM	#S	#L	MIN MAX AVG SD	NUM	#S	#L	MIN MAX AVG SD	NUM	#S	#L	MIN MAX AVG SD
SPRING 90	106	1	105	22 81 50 12	98	1	97	28 64 47 7	204	2	202	22 81 48 10
FALL 90	118	23	95	19 85 49 15	124	27	97	18 64 43 12	242	50	192	18 85 46 14
SPRING 91	113	13	100	22 83 48 14	120	33	87	18 63 40 12	233	46	187	18 83 44 13
FALL 91	115	25	90	17 84 45 16	89	12	77	18 65 41 10	204	37	167	17 84 43 14
SPRING 92	107	15	92	21 79 47 14	106	14	92	18 59 41 10	213	29	184	18 79 44 12
JUNE 92	105	13	92	15 79 47 14	127	24	103	17 62 40 11	232	37	195	15 79 43 13

DATE	AREA II BOULDER				AREA II CLIFF				AREA II ALL			
	NUM	#S	#L	MIN MAX AVG SD	NUM	#S	#L	MIN MAX AVG SD	NUM	#S	#L	MIN MAX AVG SD
SPRING 90	79	1	78	25 81 54 13	82	0	82	32 87 52 10	161	1	160	25 87 53 11
FALL 90	93	18	75	18 82 52 17	108	14	94	23 83 52 14	201	32	169	18 83 52 16
SPRING 91	92	18	74	20 78 51 17	118	29	89	19 81 44 15	210	47	163	19 81 47 16
FALL 91	83	5	78	19 78 54 15	123	10	113	19 80 49 13	206	15	191	19 80 51 14
SPRING 92	83	7	76	16 79 52 16	102	4	98	27 79 50 11	185	11	174	16 79 51 13
JUNE 92	80	4	76	17 80 54 16	103	7	96	18 71 49 12	183	12	171	17 80 51 14

DATE	AREA III BOULDER				AREA III CLIFF				AREA III ALL			
	NUM	#S	#L	MIN MAX AVG SD	NUM	#S	#L	MIN MAX AVG SD	NUM	#S	#L	MIN MAX AVG SD
SPRING 90	210	9	201	16 74 46 10	26	0	26	35 82 48 12	236	9	227	16 82 46 11
FALL 90	217	20	197	19 73 47 11	32	5	27	24 81 45 14	249	25	224	19 81 47 12
SPRING 91	216	27	189	20 73 46 12	31	5	26	24 80 45 13	247	32	215	20 80 46 12
FALL 91	197	8	189	23 74 48 11	22	1	21	26 78 45 11	219	9	210	23 78 47 11
SPRING 92	155	3	152	21 70 48 9.2	28	1	27	26 69 43 11	183	4	179	21 70 47 10
JUNE 92	221	7	214	22 76 48 10	39	6	33	15 77 43 14	260	13	247	15 77 47 11

NOTE: DATA FOR 3 PLOTS COMBINED FOR EACH HABITAT EXCEPT AREA III (5 BOULDER, 1 CLIFF).

#S = # LIMPETS < 30 mm #L = # LIMPETS > = 30 mm

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

**SIZE DISTRIBUTION OF OWL LIMPETS IN 18 CIRCULAR PLOTS DURING JUNE 1992**

LENGTH (MM)	AREA I PLOTS (# OF LIMPETS)								AREA II PLOTS (# OF LIMPETS)								AREA III PLOTS (# OF LIMPETS)							
	BOULDER				CLIFF				BOULDER				CLIFF				BOULDER					CLIFF		
	282	283	284	277	279	280	ALL	%	239	240	241	242	243	266	ALL	%	11	18	19	21	26	13	ALL	%
15	1	0	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
17	0	0	1	1	3	0	5	2	0	1	1	0	0	0	2	1	0	0	0	0	0	0	0	0
18	1	0	0	0	0	0	1	0	0	0	0	1	1	0	2	1	0	0	0	0	0	0	0	0
19	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	1	0	0	3	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	1	0	0	0	0	0	1	0	0	0	0	0	0	2	2	0	0	0	1	0	0	0	1	0
23	1	0	1	0	0	0	2	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0
24	2	0	0	4	1	1	8	3	0	0	0	0	0	0	0	0	1	1	0	0	0	1	3	1
25	0	0	0	2	0	0	2	1	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0
26	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0
27	0	0	0	0	1	2	3	1	0	0	0	0	0	1	1	1	1	0	0	0	0	1	2	1
28	0	0	1	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	2	2	0	0	4	2	0	0	0	0	0	0	0	0	1	2	0	0	0	2	5	2
30	0	0	1	4	0	1	6	3	0	1	0	0	0	0	1	1	0	2	1	0	0	0	3	1
31	1	0	1	3	0	0	5	2	1	1	0	0	0	0	2	1	0	0	1	0	0	0	1	0
32	1	0	2	1	1	0	5	2	0	0	1	0	0	0	1	1	0	4	0	0	0	2	6	2
33	0	0	1	2	1	0	4	2	0	0	0	0	0	0	0	0	0	1	0	0	2	2	5	2
34	0	0	2	2	0	0	4	2	0	0	0	0	1	2	4	2	2	1	1	0	1	2	7	3
35	0	0	2	4	2	0	8	3	0	0	0	0	0	0	0	0	1	2	1	0	0	0	4	2
36	1	0	3	1	0	0	5	2	0	0	0	1	0	1	2	1	2	4	0	0	0	3	9	3
37	0	0	1	5	1	2	9	4	0	0	0	0	0	3	6	3	1	1	1	1	1	1	6	2
38	1	0	1	1	0	0	3	1	0	0	0	0	0	3	3	2	1	4	0	0	0	1	6	2
39	1	0	1	1	2	1	6	3	0	1	0	0	0	1	3	2	1	5	1	0	0	2	9	3
40	1	1	2	2	0	1	7	3	0	0	0	0	2	2	4	2	0	5	0	1	0	2	8	3
41	0	1	0	1	0	1	3	1	0	0	0	1	0	2	5	3	1	2	0	0	0	0	3	1
42	1	0	4	2	2	0	9	4	0	0	1	0	1	1	4	2	3	2	2	0	0	1	8	3
43	1	0	2	3	1	1	8	3	0	0	0	1	1	0	3	2	2	5	1	0	0	1	9	3
44	2	0	1	3	2	3	11	5	0	1	0	0	0	3	5	3	2	4	0	1	0	1	8	3
45	0	0	0	1	0	2	3	1	0	2	0	0	0	2	5	3	0	3	1	1	0	2	7	3
46	0	0	0	2	0	1	3	1	0	1	0	0	0	4	5	3	2	7	0	1	0	0	10	4
47	1	0	1	2	1	1	6	3	0	0	0	0	0	1	2	1	6	5	2	1	0	0	14	5
48	1	0	0	0	0	2	3	1	0	2	0	2	0	1	5	3	5	1	0	1	0	1	8	3
49	2	0	2	2	1	2	9	4	0	1	0	0	0	2	4	2	5	2	0	0	0	1	8	3
50	0	2	0	0	2	2	6	3	0	1	0	0	0	1	4	2	0	4	1	2	0	1	8	3
51	0	1	2	2	2	3	10	4	0	1	2	1	1	2	7	4	3	4	0	0	0	1	8	3
52	0	0	2	2	0	0	4	2	0	0	0	4	0	3	7	4	3	2	0	2	1	1	9	3
53	0	1	1	0	0	1	3	1	0	0	1	0	0	6	8	4	3	4	0	0	1	0	8	3
54	0	0	7	1	0	1	9	4	0	0	0	0	1	2	4	2	3	4	0	2	1	1	11	4
55	0	2	1	1	2	0	6	3	0	2	0	0	1	0	5	3	1	0	1	0	2	1	5	2
56	0	0	1	0	1	1	3	1	0	0	1	1	0	3	6	3	0	1	1	1	0	0	3	1
57	3	0	1	0	1	0	5	2	0	0	0	0	0	1	1	1	1	3	1	1	1	0	7	3
58	0	2	3	0	3	1	9	4	0	0	0	0	0	4	6	3	2	0	1	3	2	0	8	3
59	1	0	0	0	0	1	2	1	0	0	1	2	0	3	7	4	0	0	0	0	1	0	1	0
60	2	1	0	0	0	0	3	1	0	0	0	0	4	2	6	3	0	0	0	1	1	0	2	1
61	0	0	0	0	0	0	0	0	0	1	1	2	0	1	5	3	1	0	3	1	0	1	6	2
62	0	0	0	1	0	1	2	1	0	2	1	0	0	3	6	3	1	0	0	4	1	0	6	2
63	1	2	1	0	0	0	4	2	0	0	1	0	0	2	3	2	0	1	1	0	1	1	4	2
64	1	1	1	0	0	0	3	1	0	0	1	0	0	1	2	1	0	0	1	3	0	1	5	2
65	2	0	0	0	0	0	2	1	0	0	1	0	0	1	2	1	0	0	1	0	1	0	2	1
66	0	0	0	0	0	0	0	0	0	0	1	1	0	3	5	3	0	0	3	0	1	0	4	2
67	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	3	0	1	0	4	2
68	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	1	0
69	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	1	0	0	1	0	0	0	1	0

# SIZE DISTRIBUTION OF OWL LIMPETS IN 18 CIRCULAR PLOTS DURING JUNE 1992

LENGTH (MM)	AREA I PLOTS (# OF LIMPETS)								AREA II PLOTS (# OF LIMPETS)								AREA III PLOTS (# OF LIMPETS)								
	BOULDER			CLIFF			ALL	%	BOULDER			CLIFF			ALL	%	BOULDER					CLIFF	ALL	%	
	282	283	284	277	279	280			239	240	241	242	243	266			11	18	19	21	26	13			
71	2	0	0	0	0	0	2	1	0	2	1	0	1	0	4	2	0	0	1	0	0	0	0	1	0
72	0	0	1	0	0	0	1	0	0	1	3	0	0	0	4	2	0	0	0	0	1	0	0	1	0
73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	
74	1	0	0	0	0	0	1	0	0	0	5	0	0	0	5	3	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	1	0	0	0	0	0	1	0	0	0	3	0	0	0	3	2	0	0	1	0	0	0	0	1	0
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
79	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL #	37	14	54	63	32	32	232	100	25	23	32	18	14	71	182	100	55	86	33	27	20	39	260	100	
MIN SIZE	15	40	15	17	17	24	15		22	17	17	18	18	22	17		24	24	22	37	33	15	15		
MAX SIZE	79	64	72	62	58	62	79		59	72	80	68	71	66	80		62	63	76	64	72	77	77		
AVG SIZE	47	54	44	37	41	45	42.7		45	48	64	51	49	49	50.8		46	44	53	54	55	43	47		
ST DEV	19	8	12	10	13	9	13		10	15	14	12	14	11	14.3		8	8	14	8	12	14	11		

**RELATIVE ABUNDANCE OF WOOLLY SCULPINS  
IN TIDEPOOLS IN JUNE 1992**

CABR I	NUMBER (BY RANK) OF SCULPINS PER POOL			
POOL #	0 (NONE)	1 (RARE)	2-5 (COMMON)	>5 (ABUNDANT)
1			X	
2			X	
3		X		
4	X			
5		X		
6			X	
7		X		
8		X		
9			X	
10			X	
SUM	1	4	5	0

CABR II	NUMBER (BY RANK) OF SCULPINS PER POOL			
POOL #	0 (NONE)	1 (RARE)	2-5 (COMMON)	>5 (ABUNDANT)
1				X
2			X	
3			X	
4	X			
5				X
6				X
7			X	
8			X	
9		X		
10			X	
SUM	1	1	5	3

CABR III	NUMBER (BY RANK) OF SCULPINS PER POOL			
POOL #	0 (NONE)	1 (RARE)	2-5 (COMMON)	>5 (ABUNDANT)
1		X		
2			X	
3		X		
4				X
5			X	
6				X
7			X	
8			X	
9			X	
10				X
SUM	0	2	5	3

# WOOLLY SCULPIN SUMMARY DATA

NUMBER OF POOLS (OUT OF 10 TOTAL) FOR EACH OF FOUR RELATIVE ABUNDANCE CATEGORIES OF WOOLLY SCULPINS.  
DATA ARE AVAILABLE FOR THE MOST RECENT 2 SURVEYS OF 3 SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I SCULPIN ABUNDANCE				AREA II SCULPIN ABUNDANCE				AREA III SCULPIN ABUNDANCE			
	0 (NONE)	1 (RARE)	2-5 (COMMON)	>5 (ABUNDANT)	0 (NONE)	1 (RARE)	2-5 (COMMON)	>5 (ABUNDANT)	0 (NONE)	1 (RARE)	2-5 (COMMON)	>5 (ABUNDANT)
SPRING 90	-	-	-	-	-	-	-	-	-	-	-	-
FALL 90	-	-	-	-	-	-	-	-	-	-	-	-
SPRING 91	-	-	-	-	-	-	-	-	-	-	-	-
FALL 91	-	-	-	-	-	-	-	-	-	-	-	-
SPRING 92	6	1	2	1	6	0	3	1	2	5	2	1
JUNE 92	1	4	5	0	1	1	5	3	0	2	5	3

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

**ABUNDANCE AND DISTRIBUTION OF GROUND COVER  
ALONG 10 m LINE-INTERCEPT TRANSECTS IN JUNE 1992**

CABR AREA I	LINE TRANSECTS (% COVER)								
	TURF ZONE			GRASS ZONE			KELP ZONE		
	TAXA	210	237	AVG	211	238	AVG	212	236
FEATHER BOA KELP	9	0	5	11	1	6	54	33	43
SARGASSUM WEED	0	0	0	0	0	0	0	0	0
RED ALGAL TURF	65	98	81	5	29	17	7	39	23
SURF GRASS	25	0	13	85	69	77	11	28	20
AGGREGATING ANEMONE	0	2	1	0	0	0	0	0	0
OTHER BIOTA	1	0	0	0	0	0	28	0	14
BARE SUBSTRATE	0	0	0	0	0	0	0	1	0

CABR AREA II	LINE TRANSECTS (% COVER)								
	TURF ZONE			GRASS ZONE			KELP ZONE		
	TAXA	244	270	AVG	267	271	AVG	268	272
FEATHER BOA KELP	0	16	8	4	28	16	48	47	48
SARGASSUM WEED	1	5	3	0	6	3	0	0	0
RED ALGAL TURF	93	51	72	4	7	6	14	8	11
SURF GRASS	1	23	12	93	55	74	13	44	29
AGGREGATING ANEMONE	3	0	2	0	0	0	0	0	0
OTHER BIOTA	0	2	1	0	2	1	24	1	12
BARE SUBSTRATE	1	3	2	0	2	1	0	0	0

CABR AREA III	LINE TRANSECTS (% COVER)								
	TURF ZONE			GRASS ZONE			KELP ZONE		
	TAXA	1	8	AVG	5	7	AVG	2	4
FEATHER BOA KELP	0	0	0	2	2	2	42	58	50
SARGASSUM WEED	0	0	0	0	4	2	6	9	7
RED ALGAL TURF	89	99	94	13	26	19	34	15	24
SURF GRASS	8	0	4	85	68	76	10	13	11
AGGREGATING ANEMONE	2	1	2	0	0	0	0	0	0
OTHER BIOTA	0	0	0	0	0	0	6	5	6
BARE SUBSTRATE	0	0	0	0	0	0	3	1	2

# LINE INTERCEPT SPECIES SUMMARY DATA

MEAN PERCENT COVER (N=2) FOR 7 TAXA IN EACH OF 3 INTERTIDAL ZONES DOMINATED BY RED ALGAL TURF, SURF GRASS, AND FEATHER BOA KELP RESPECTIVELY. DATA ARE PRESENTED FOR 6 SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF 3 SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I TURF							AREA I GRASS							AREA I KELP						
	BK	SW	RT	SG	AA	OB	BS	BK	SW	RT	SG	AA	OB	BS	BK	SW	RT	SG	AA	OB	BS
SPRING 90	3	0	87	5	2	0	3	10	0	25	53	0	1	11	44	0	34	10	0	5	7
FALL 90	0	0	51	14	1	0	4	1	0	23	72	0	0	4	31	0	36	16	0	8	9
SPRING 91	0	0	88	8	2	0	2	1	0	26	70	0	0	3	14	0	66	8	0	12	0
FALL 91	1	0	83	14	1	0	1	10	0	17	71	0	0	3	54	2	21	19	0	4	1
SPRING 92	0	0	81	17	2	0	0	0	0	21	79	0	0	0	51	0	28	20	0	0	1
JUNE 92	5	0	81	13	1	0	0	6	0	17	77	0	0	0	43	0	23	20	0	14	0

DATE	AREA II TURF							AREA II GRASS							AREA II KELP						
	BK	SW	RT	SG	AA	OB	BS	BK	SW	RT	SG	AA	OB	BS	BK	SW	RT	SG	AA	OB	BS
SPRING 90	6	0	73	2	1	0	18	20	6	26	40	0	1	7	55	0	28	11	0	1	5
FALL 90	3	0	75	5	1	0	17	8	0	16	69	0	2	5	42	0	32	17	3	3	3
SPRING 91	0	0	74	4	0	2	20	10	6	10	62	0	8	4	11	0	64	24	0	0	2
FALL 91	1	1	71	8	1	0	19	17	0	8	70	0	5	0	29	6	23	35	0	4	0
SPRING 92	1	3	79	11	1	0	5	13	3	9	72	0	4	0	30	0	20	47	0	3	0
JUNE 92	8	3	72	12	2	1	2	16	3	6	74	0	1	1	48	0	11	29	0	12	0

DATE	AREA III TURF							AREA III GRASS							AREA III KELP						
	BK	SW	RT	SG	AA	OB	BS	BK	SW	RT	SG	AA	OB	BS	BK	SW	RT	SG	AA	OB	BS
SPRING 90	0	0	90	4	2	0	4	2	3	25	60	0	1	9	54	0	34	4	0	2	6
FALL 90	0	0	80	4	1	1	14	4	2	15	72	0	0	7	36	0	47	7	0	3	7
SPRING 91	0	1	87	3	2	0	6	6	0	16	58	0	0	20	22	14	32	7	0	5	21
FALL 91	0	0	79	6	2	0	14	4	3	16	70	0	0	7	25	4	44	14	0	11	2
SPRING 92	0	0	94	3	1	0	2	4	8	26	61	0	0	1	40	8	44	5	0	3	0
JUNE 92	0	0	94	4	2	0	0	2	2	19	76	0	0	0	50	7	24	11	0	6	2

BK=BOA KELP SW=SARGASSUM WEED RT=RED ALGAL TURF SG=SURF GRASS

AA=AGGREGATING ANEMONE OB=OTHER BIGTA BS=BARE SUBSTRATE

**ABUNDANCE OF ABALONE AND SEA STARS RECORDED  
DURING 30 MIN TIMED SEARCHES IN JUNE 1992**

AREA	NUMBER OF ABALONE				TOTAL #
	BLACK	GREEN	PINK	RED	
I	0	0	0	0	0
II	0	1	0	0	1
III	0	0	0	0	0
ALL	0	1	0	0	1

AREA	NUMBER OF SEA STARS				TOTAL #
	OCHRE	BLUE	BAT	FRAGILE	
I	0	1	1	0	2
II	0	0	4	0	4
III	0	0	12	1	13
ALL	0	1	17	1	19

## ABALONE AND SEA STAR SUMMARY DATA

NUMBER OF ABALONE AND SEASTARS OBSERVED DURING TIMED SEARCHES (APP. 30 min DURATION).  
DATA ARE PRESENTED FOR 6 SEASONAL SURVEYS (FEB 1990-JUNE 1992) OF 3 SEPARATE AREAS AT THE CABRILLO NATIONAL MONUMENT.

DATE	AREA I			AREA II			AREA III			ALL		
	ABALONE		SEASTARS	ABALONE		SEASTARS	ABALONE		SEASTARS	ABALONE		SEASTARS
	BLACK	OTHER	OCHRE	BLACK	OTHER	OCHRE	BLACK	OTHER	OCHRE	BLACK	OTHER	OCHRE
SPRING 90	0	1	0	0	0	0	0	0	0	0	1	0
FALL 90	0	1	0	0	0	0	0	0	0	0	1	0
SPRING 91	0	0	0	0	0	0	0	0	0	0	0	0
FALL 91	0	0	0	0	0	0	0	0	0	0	0	0
SPRING 92	0	0	0	0	0	0	0	0	0	0	0	0
JUNE 92	0	0	0	0	1	0	0	0	0	0	1	0

• BAT STARS NOT COUNTED

CABRILLO NATIONAL MONUMENT INTERTIDAL SURVEY

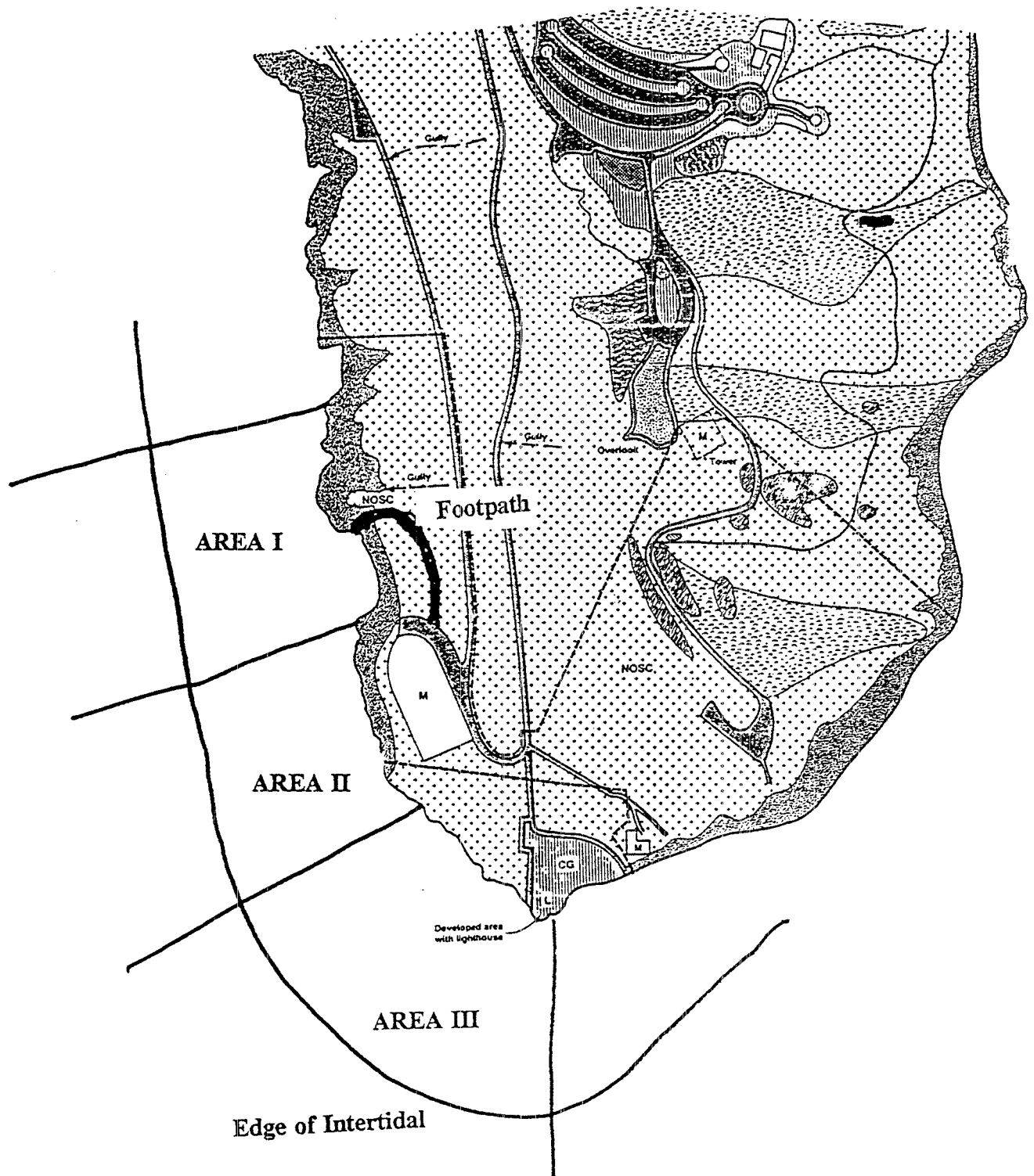
# SUMMARY OF INTERTIDAL RESOURCE TRENDS AT CABRILLO NATIONAL MONUMENT: SPRING 1990 TO JUNE 1992

INDEX TAXA	AREA I						AREA II						AREA III						ALL AREAS					
	S90	F90	S91	F91	S92	J92	S90	F90	S91	F91	S92	J92	S90	F90	S91	F91	S92	J92	S90	F90	S91	F91	S92	J92
GOOSE BARNACLES ^	5	5	5	5	5	5	4	3	3	2	3	3	3	7	3	3	4	3	4	5	3	3	4	4
THATCHED BARNACLES ^	20	16	20	13	19	11	30	17	26	21	7	13	22	29	26	24	12	13	24	21	24	19	13	12
WHITE ACORN BARNACLE ^	2	13	13	12	3	18	12	26	28	23	5	18	13	26	22	42	34	35	9	22	21	26	14	24
ROCKWEED (PELVETIA) ^	59	62	57	77	60	66	71	72	68	75	77	71	84	74	65	76	71	86	71	69	63	76	69	74
CALIFORNIA MUSSEL ^	16	9	6	9	7	10	55	30	20	18	10	7	47	34	28	25	21	26	39	24	18	17	13	14
BARE RK (PHOTOPLOTS) ^	33	30	35	28	22	29	27	18	27	15	16	20	29	25	33	21	22	26	30	24	32	21	20	25
OWL LIMPETS: X #"	34	40	39	34	36	39	27	34	35	34	31	31	39	42	41	37	31	43	33	38	38	35	32	38
X SIZE(mm)	48	46	44	43	44	43	53	52	47	51	51	51	46	47	46	47	47	47	49	48	45	47	47	47
WOOLLY SCULPINS"	-	-	-	-	1	2	-	-	-	-	2	3	-	-	-	-	2	3	-	-	-	-	2	3
RED TURF (CORALLINA+) ^	87	81	88	83	81	81	73	75	74	71	79	72	90	80	87	79	94	94	83	79	83	78	85	82
AGGREGATING ANEMONE ^	2	1	2	1	2	1	1	1	0	1	1	2	2	1	2	2	1	2	2	1	1	2	1	2
SURF GRASS ^	53	72	70	71	79	77	40	69	62	70	72	74	60	72	58	70	61	76	51	71	63	70	71	76
SARGASSUM WEED ^	0	0	0	0	0	0	6	0	6	0	3	3	3	2	0	3	8	2	3	1	2	1	4	2
FEATHER BOA KELP ^	44	31	14	54	51	43	55	42	11	29	30	48	54	36	22	25	40	50	51	36	16	36	40	47
BARE (LINE TRANSECTS) ^	7	6	2	2	0	0	10	8	9	6	2	1	6	9	16	8	1	1	8	8	9	5	1	1
GC RE SEASTAR ~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLACK ABALONE ~	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

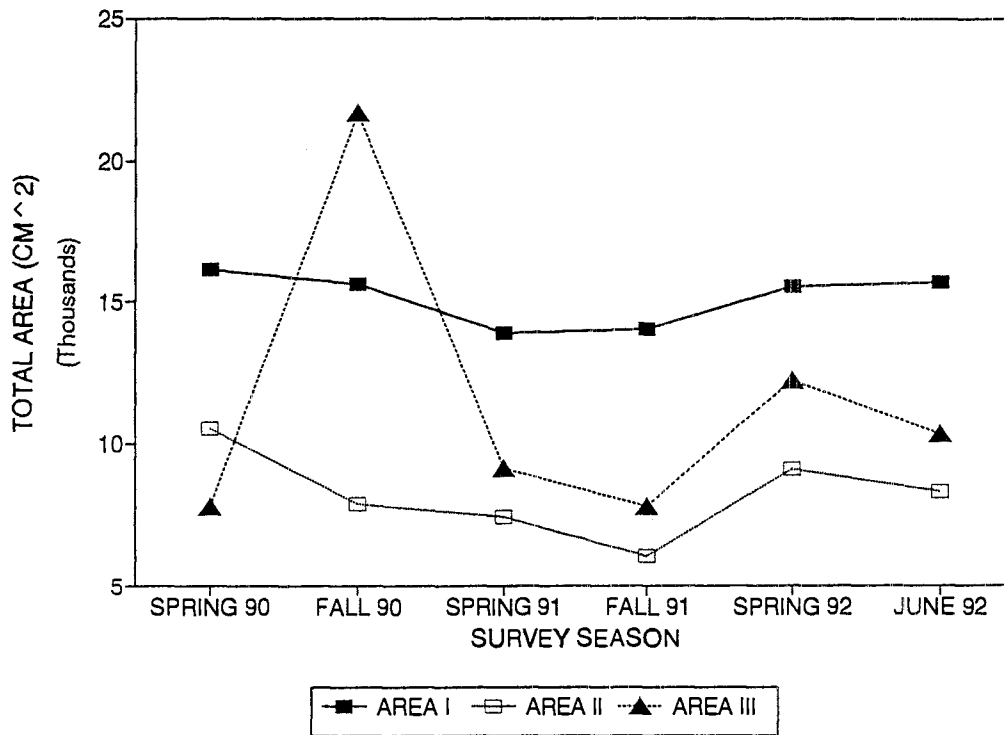
^ = PERCENT COVER IN FIXED PLOTS " = MEAN COUNTS IN FIXED PLOTS ~ = COUNTS IN TIMED SEARCHES

S = SPRING F = FALL J = JUNE

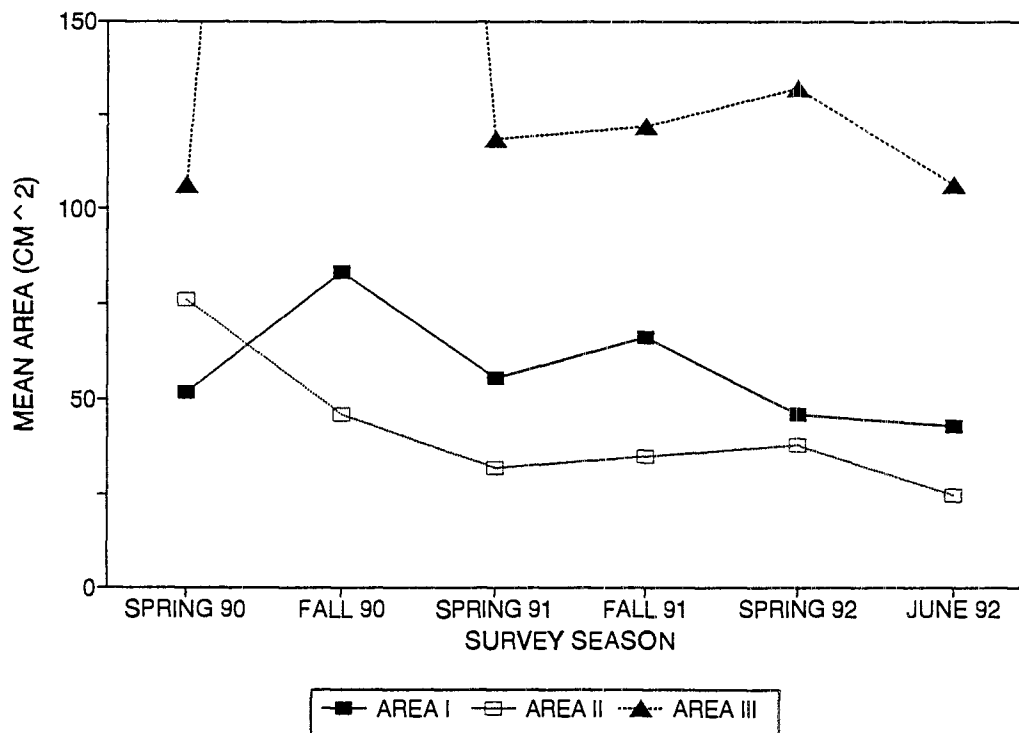
Figure 1. Public Access and Visitor Use Areas in Cabrillo National Monument, California.



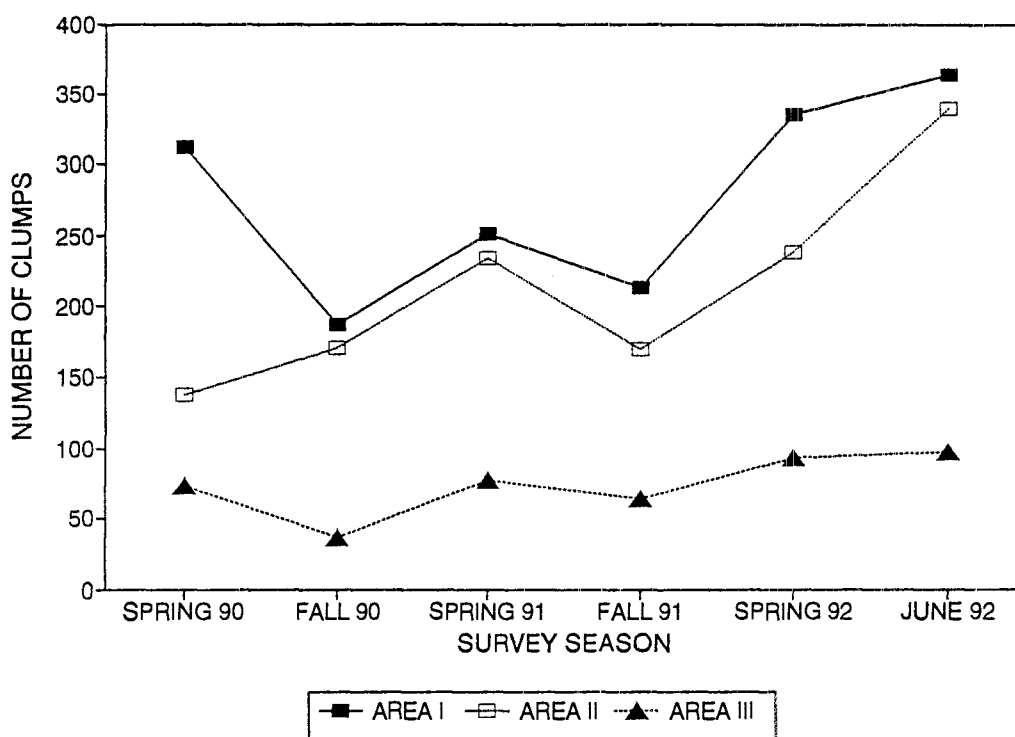
### TOTAL AREA OF GOOSE BARNACLE CLUMPS SURVEYED BY BAND TRANSECTS



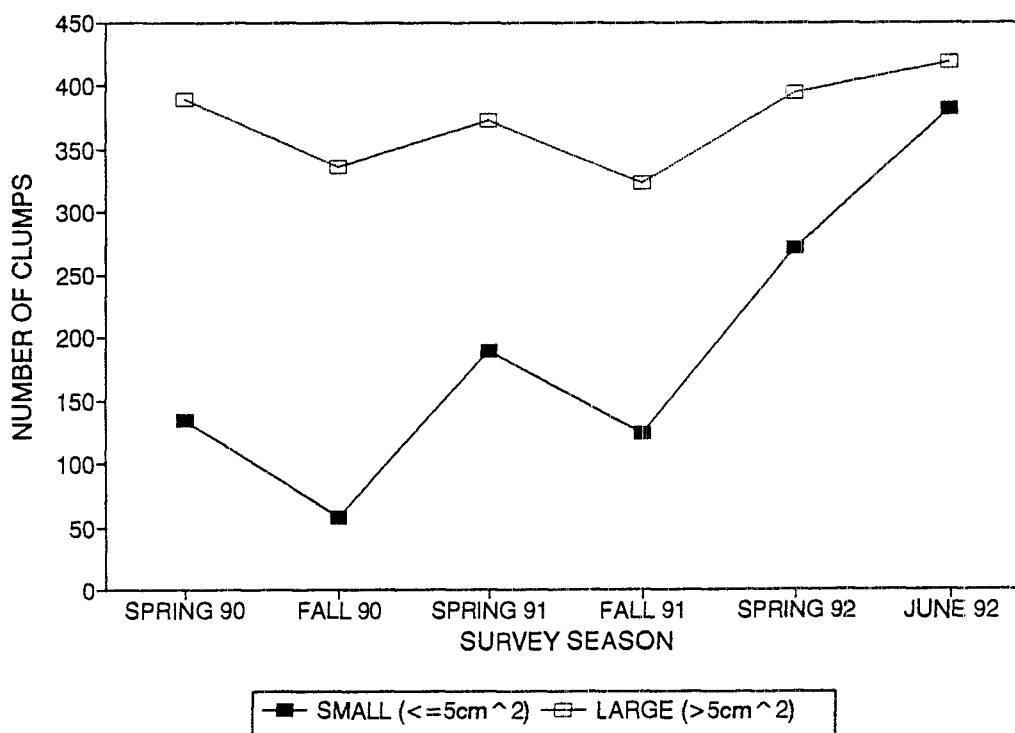
### AVERAGE SIZE OF GOOSE BARNACLE CLUMPS SURVEYED BY BAND TRANSECTS



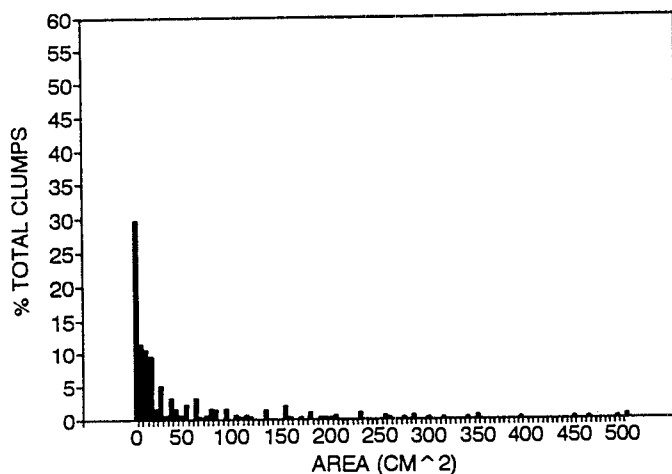
### TOTAL NUMBER OF GOOSE BARNACLE CLUMPS SURVEYED BY BAND TRANSECTS



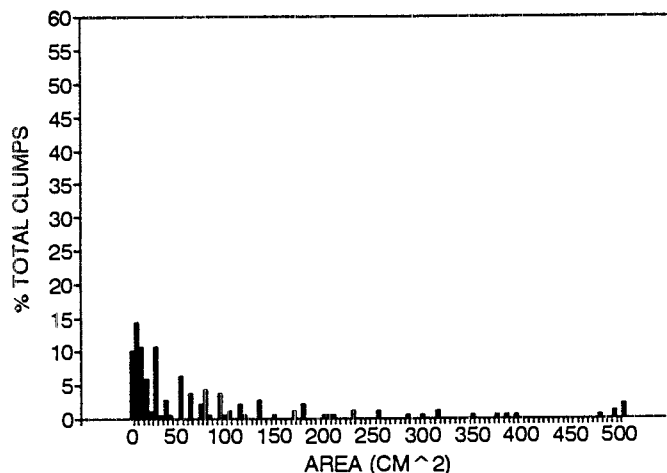
### # OF SMALL VS LARGE BARNACLE CLUMPS SURVEYED BY BAND TRANSECTS



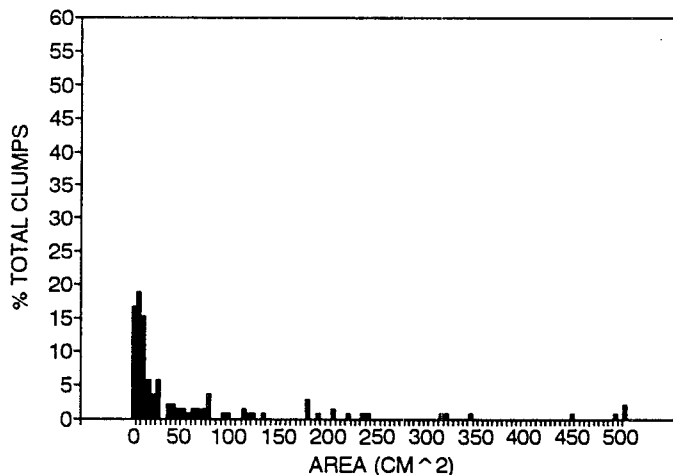
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA I DURING SPRING 1990



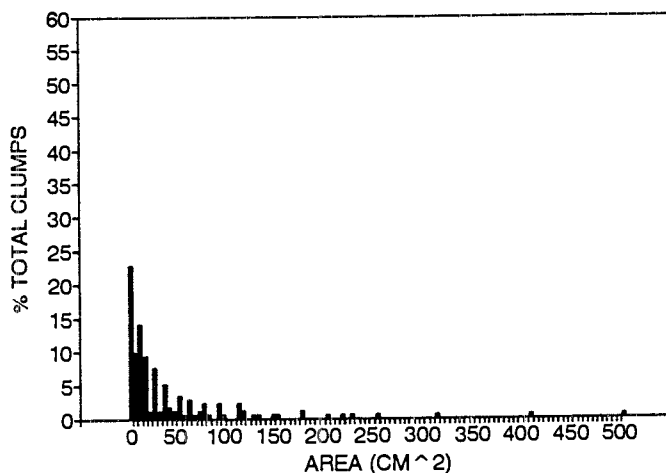
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA I DURING FALL 1990



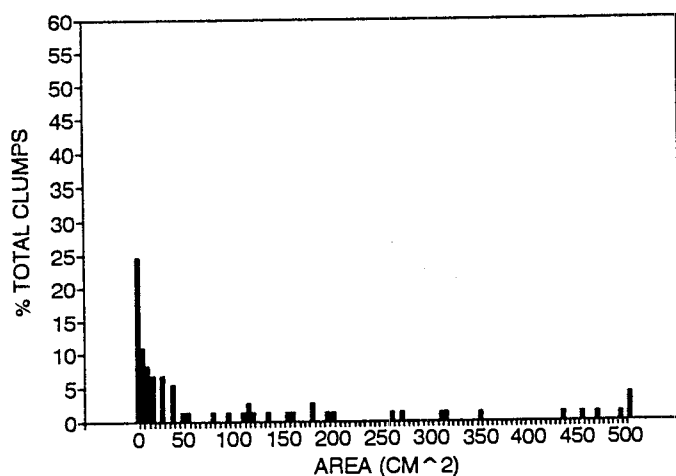
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA II DURING SPRING 1990



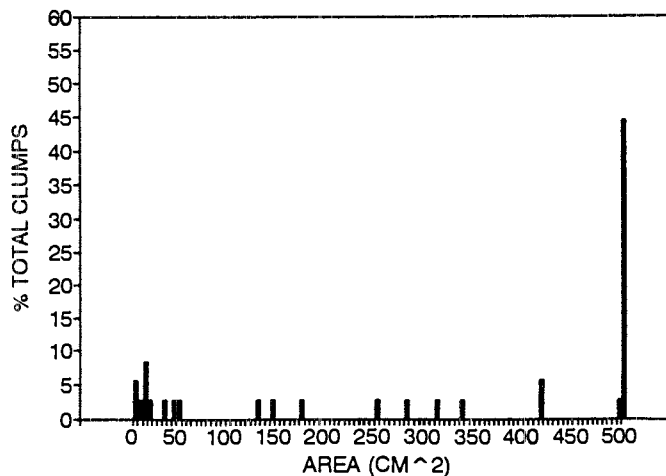
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA II DURING FALL 1990



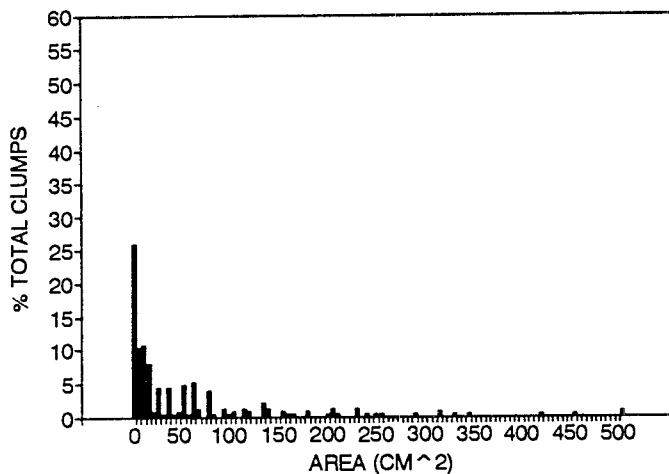
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA III DURING SPRING 1990



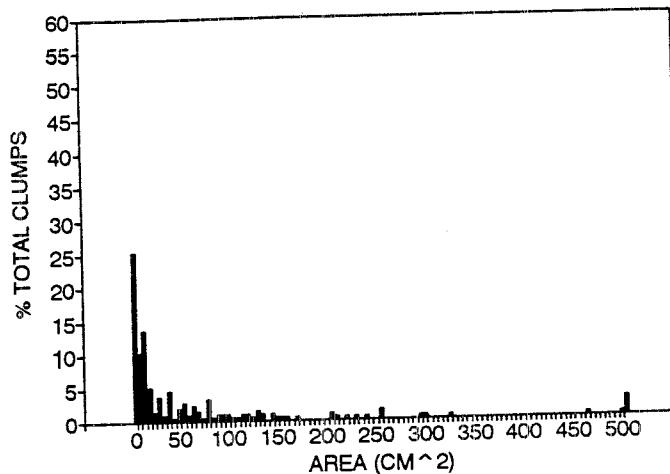
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA III DURING FALL 1990



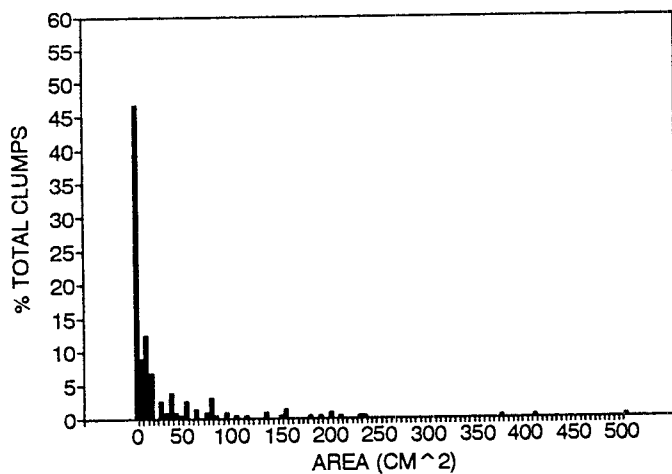
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA I DURING SPRING 1991



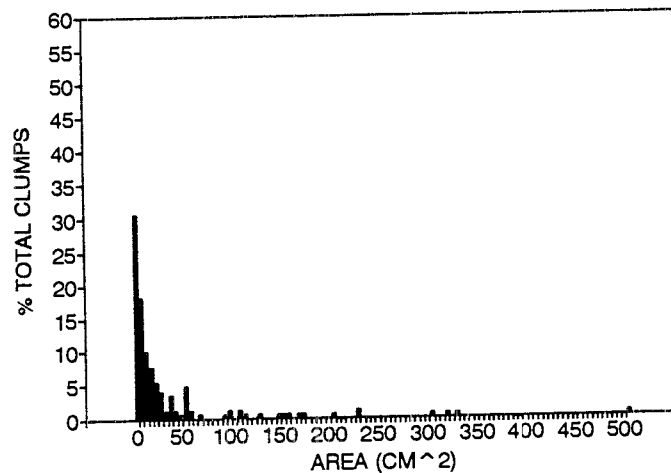
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA I DURING FALL 1991



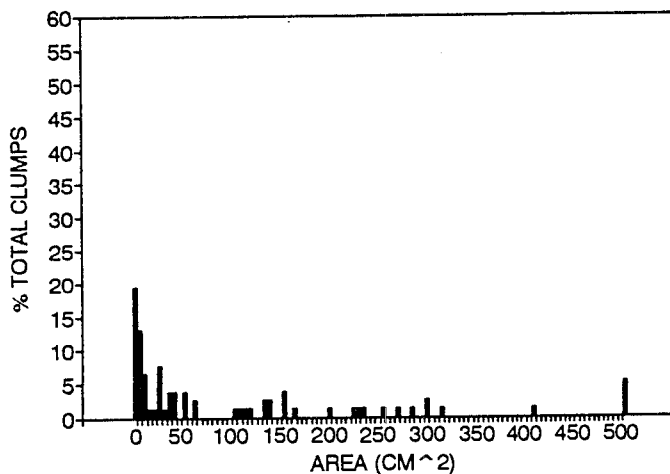
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA II DURING SPRING 1991



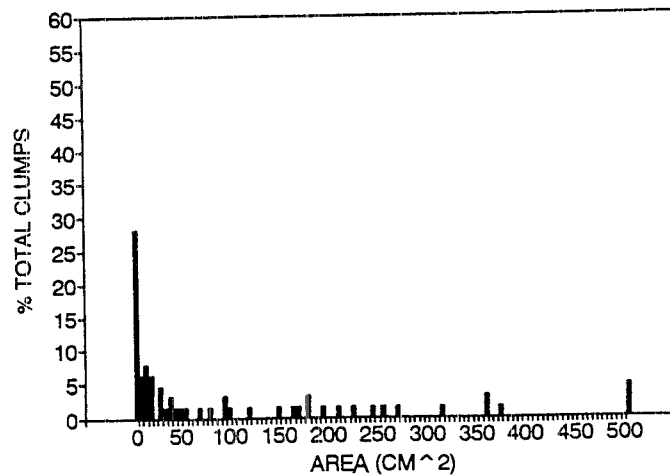
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA II DURING FALL 1991



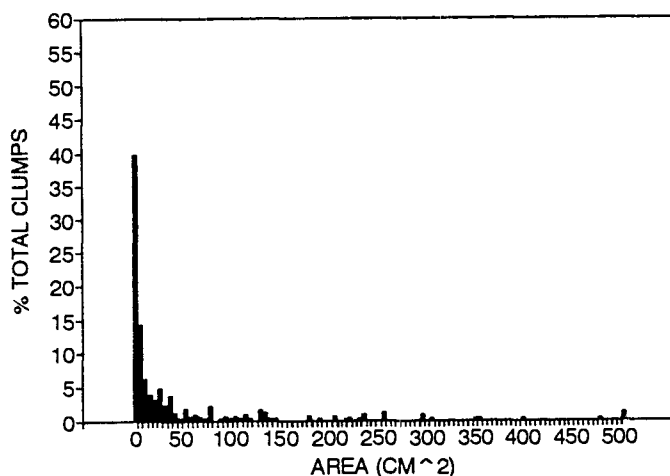
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA III DURING SPRING 1991



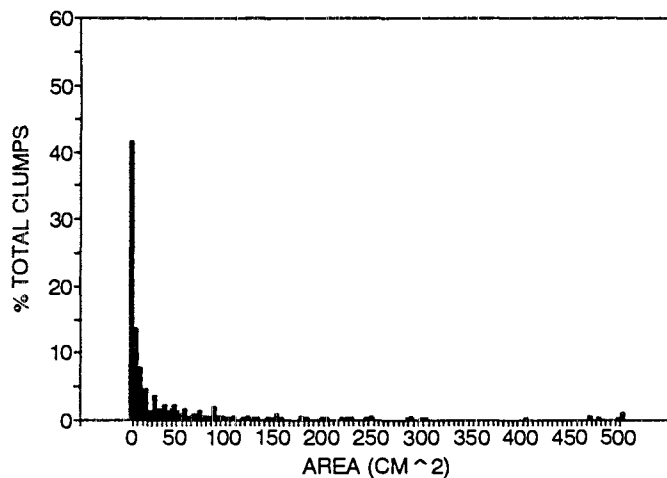
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA III DURING FALL 1991



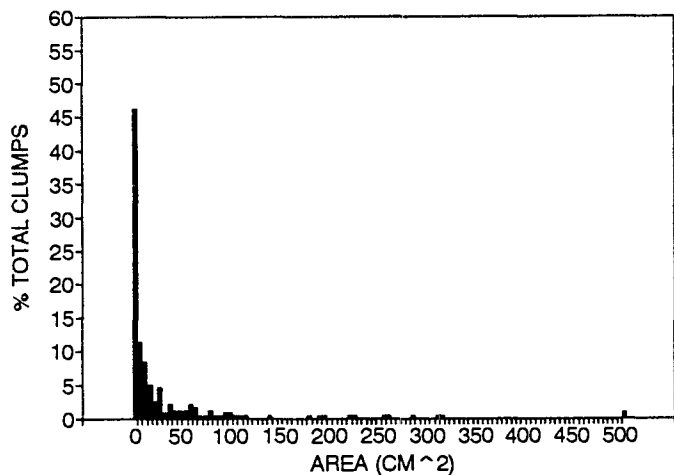
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA I DURING SPRING 1992



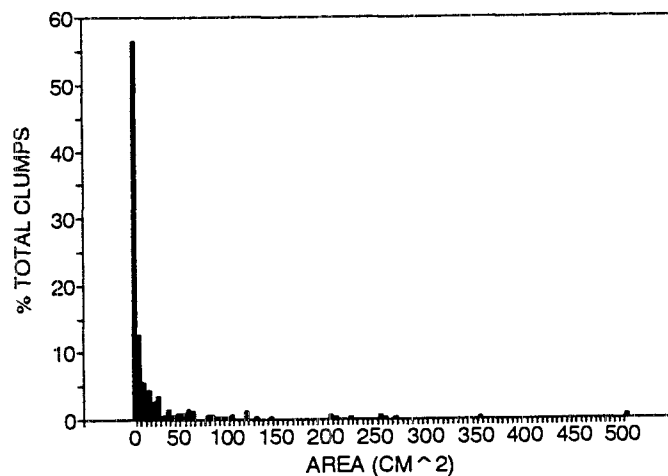
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA I DURING JUNE 1992



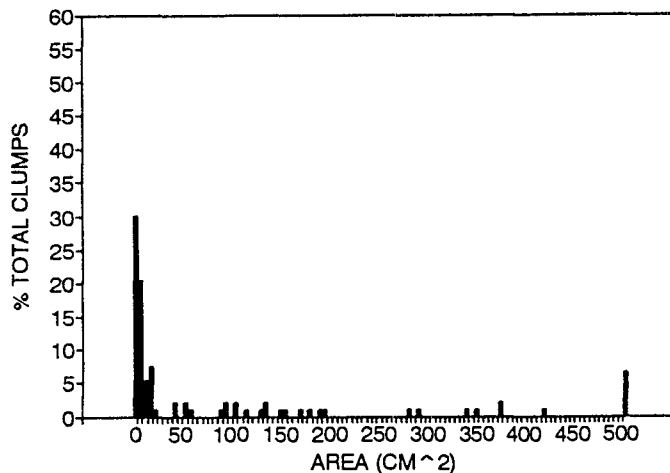
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA II DURING SPRING 1992



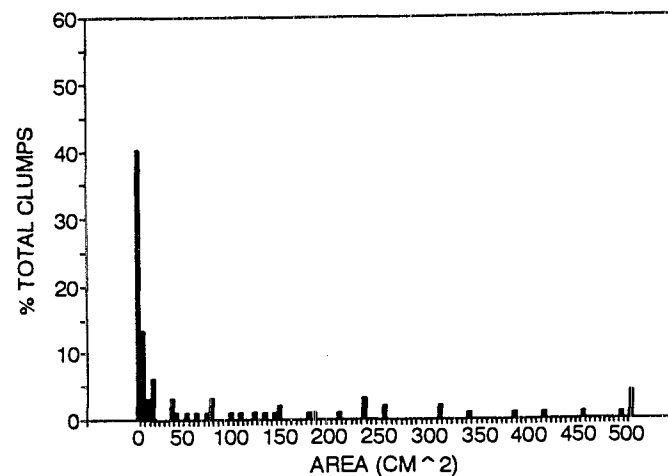
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA II DURING JUNE 1992



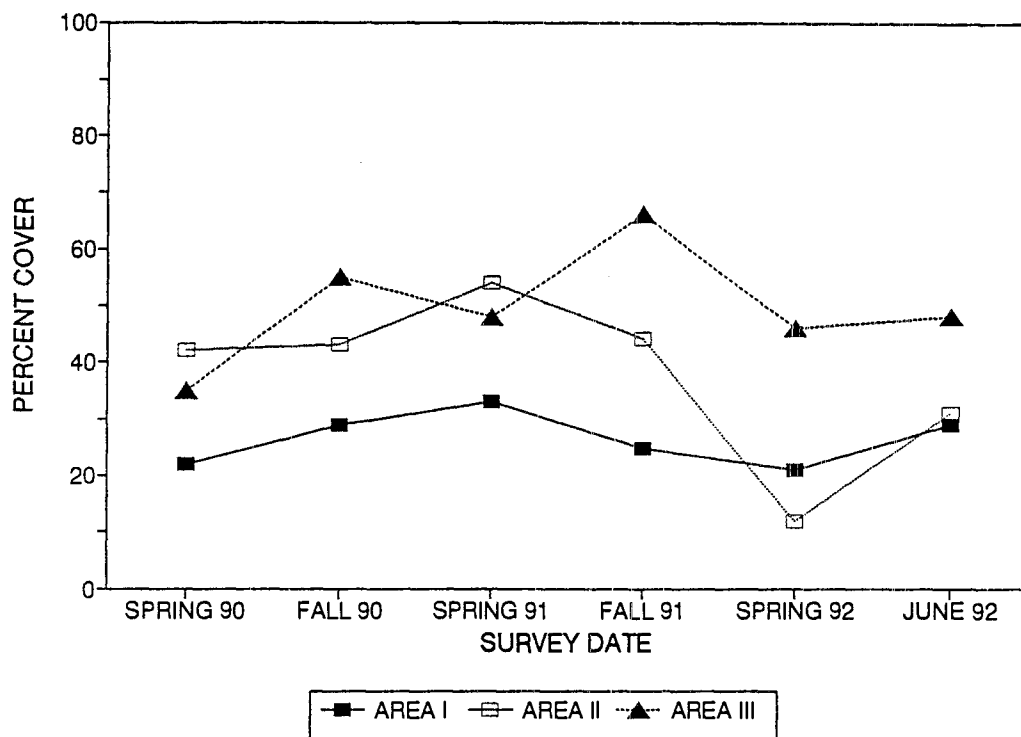
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA III DURING SPRING 1992



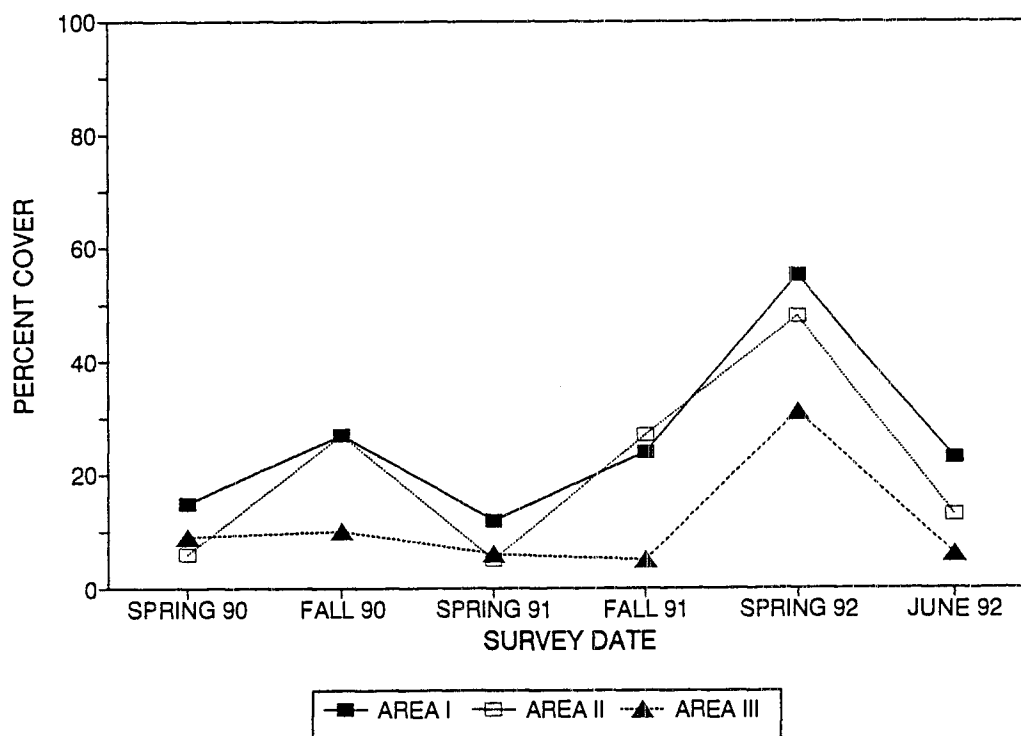
GOOSE BARNACLE CLUMP SIZE FREQUENCY  
FOR AREA III DURING JUNE 1992

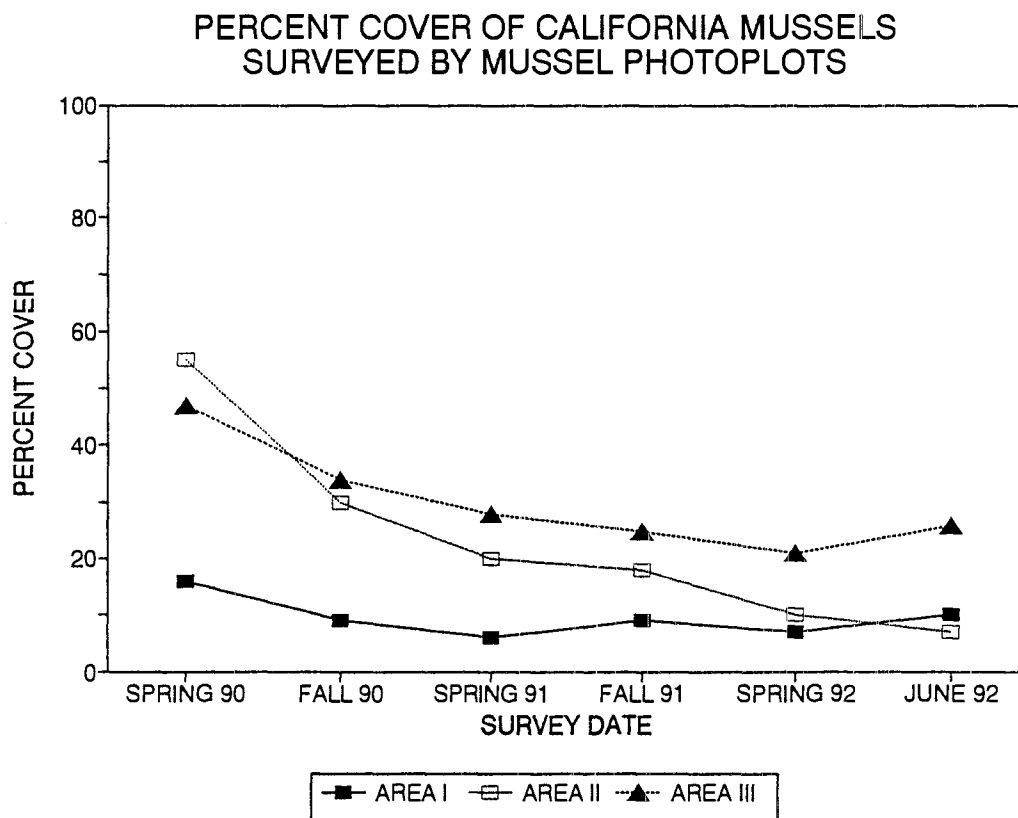
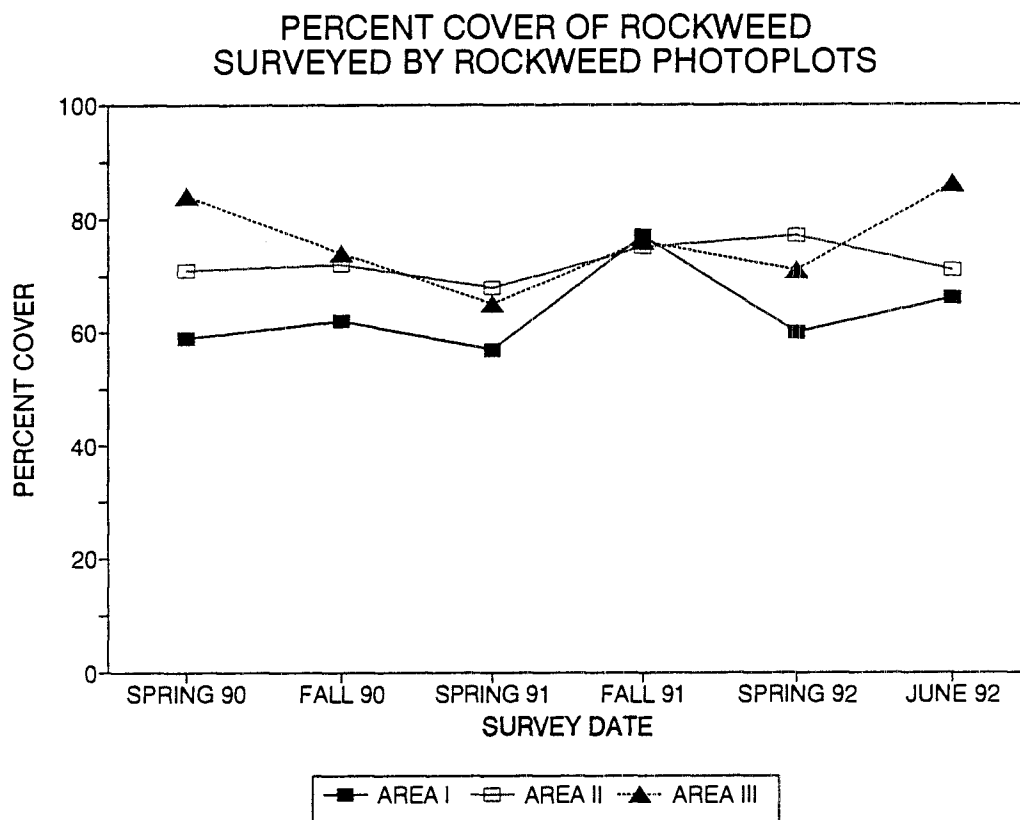


### % COVER OF ACORN AND THATCHED BARNACLES SURVEYED BY BARNACLE PHOTOPLOTS

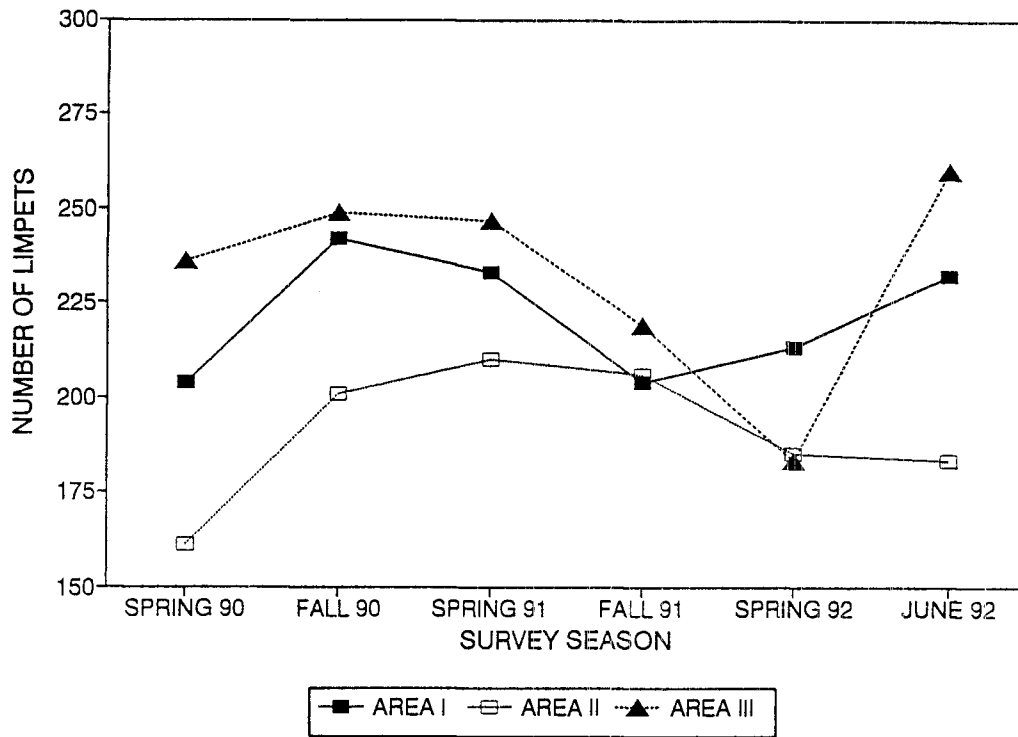


### PERCENT COVER OF OTHER PLANTS SURVEYED BY BARNACLE PHOTOPLOTS

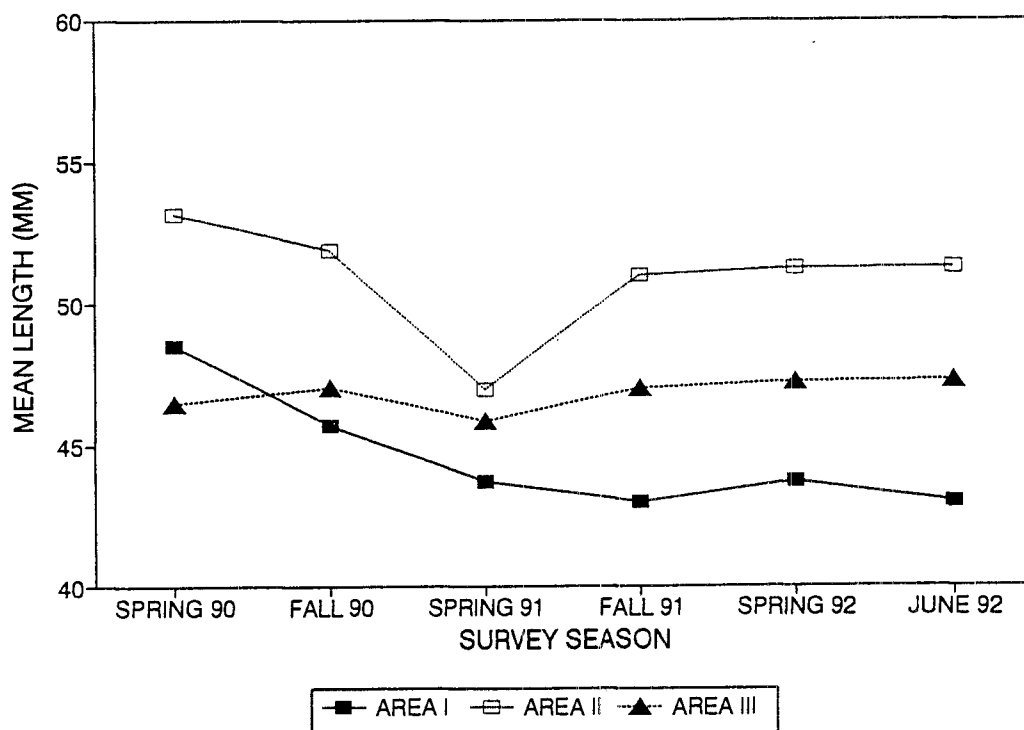




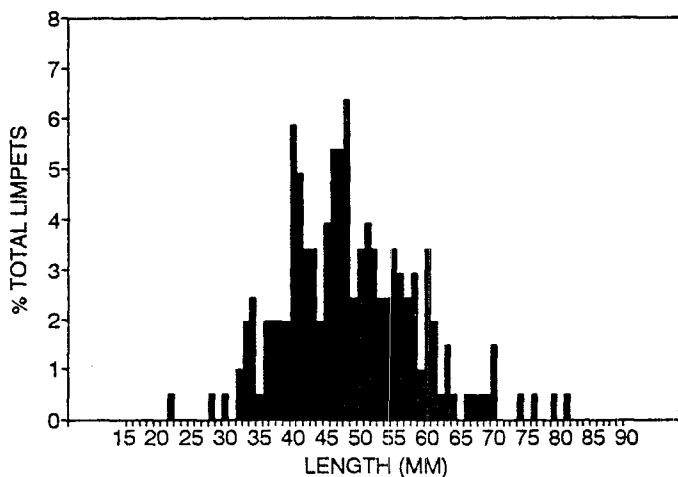
### TOTAL NUMBER OF OWL LIMPETS SURVEYED BY CIRCULAR PLOTS



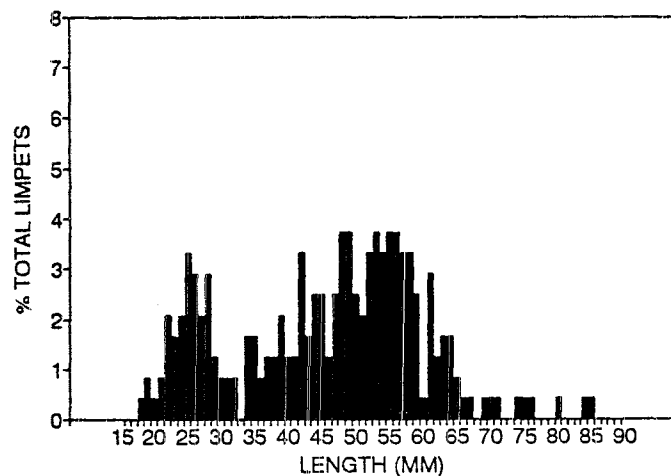
### AVERAGE SIZE OF OWL LIMPETS SURVEYED BY CIRCULAR PLOTS



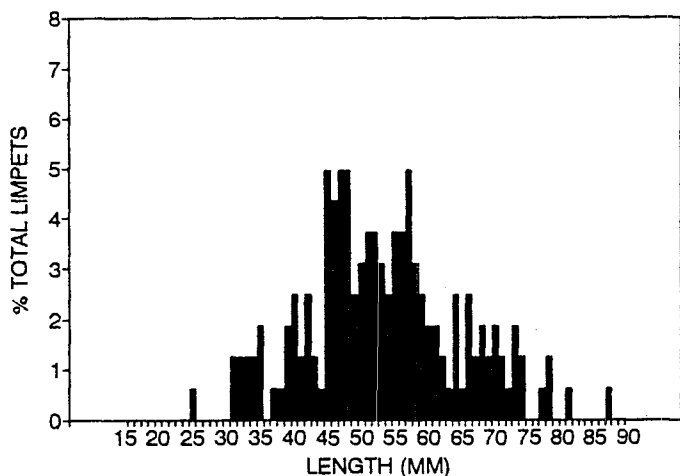
OWL LIMPET LENGTH FREQUENCY  
FOR AREA I DURING SPRING 1990



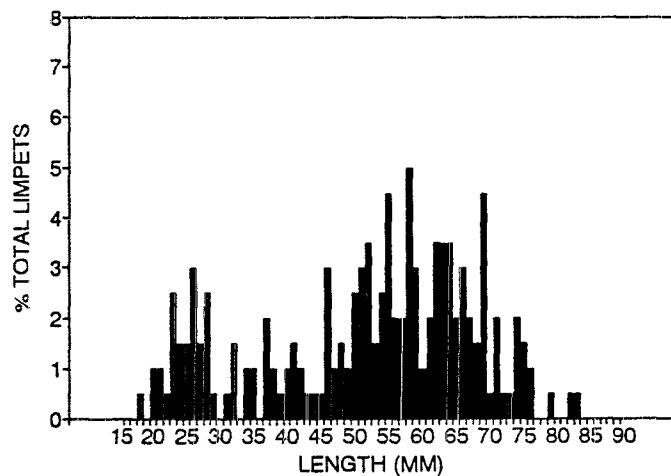
OWL LIMPET LENGTH FREQUENCY  
FOR AREA I DURING FALL 1990



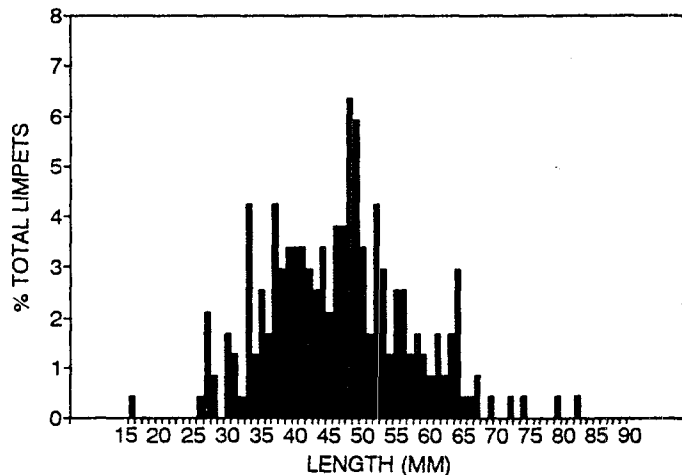
OWL LIMPET LENGTH FREQUENCY  
FOR AREA II DURING SPRING 1990



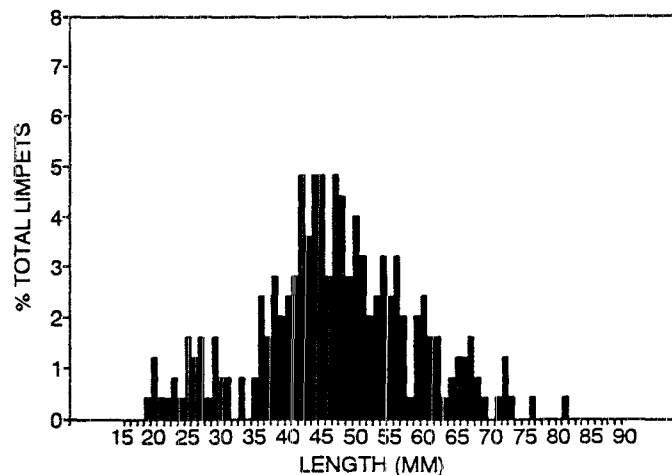
OWL LIMPET LENGTH FREQUENCY  
FOR AREA II DURING FALL 1990



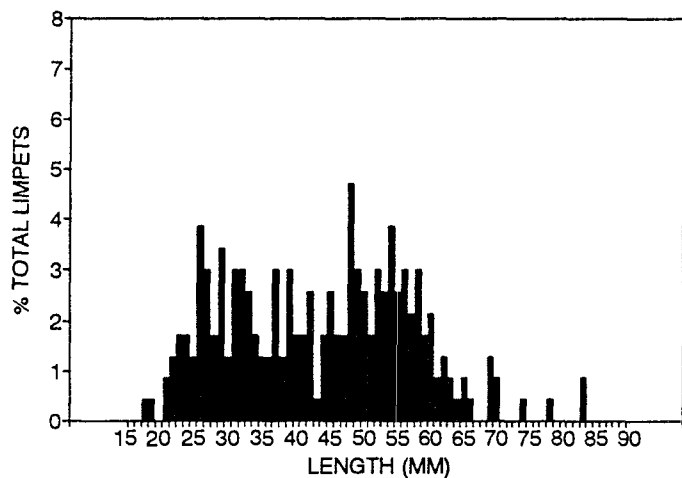
OWL LIMPET LENGTH FREQUENCY  
FOR AREA III DURING SPRING 1990



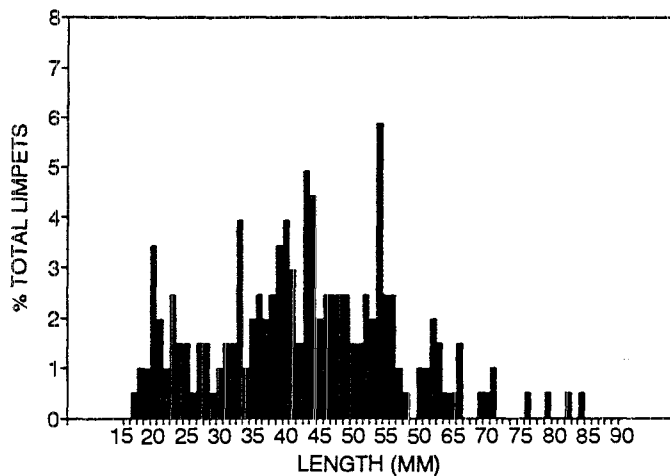
OWL LIMPET LENGTH FREQUENCY  
FOR AREA III DURING FALL 1990



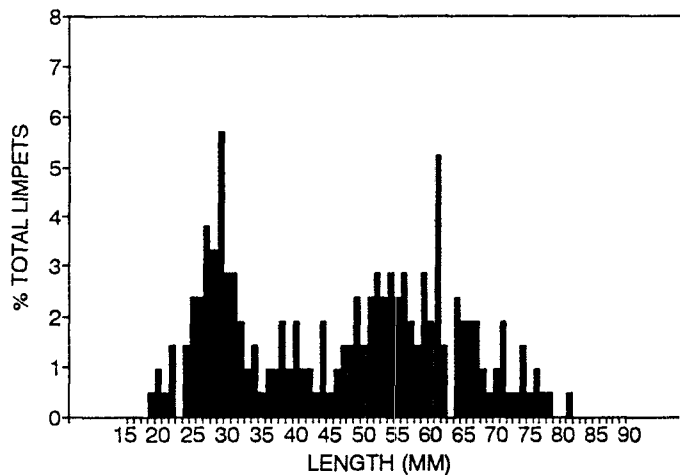
OWL LIMPET LENGTH FREQUENCY  
FOR AREA I DURING SPRING 1991



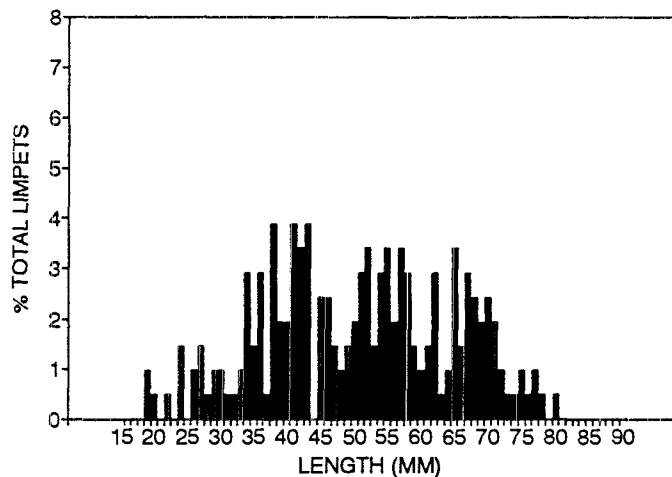
OWL LIMPET LENGTH FREQUENCY  
FOR AREA I DURING FALL 1991



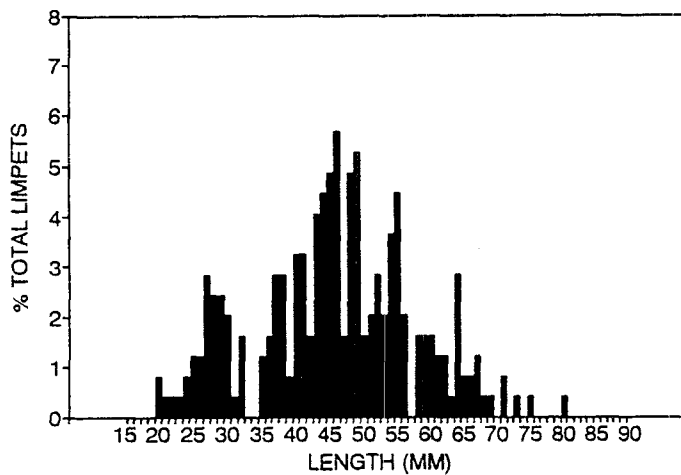
OWL LIMPET LENGTH FREQUENCY  
FOR AREA II DURING SPRING 1991



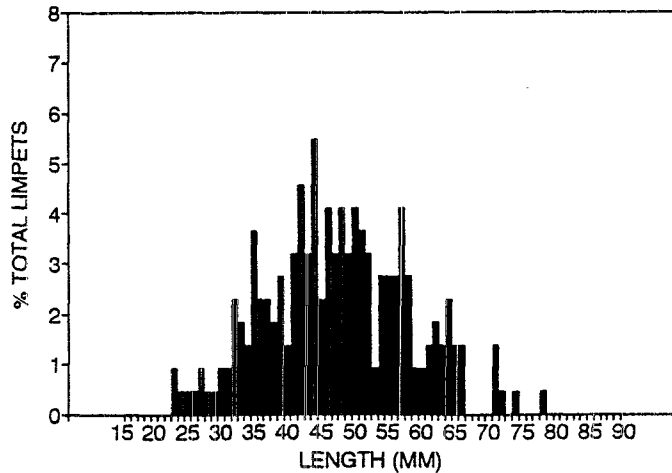
OWL LIMPET LENGTH FREQUENCY  
FOR AREA II DURING FALL 1991



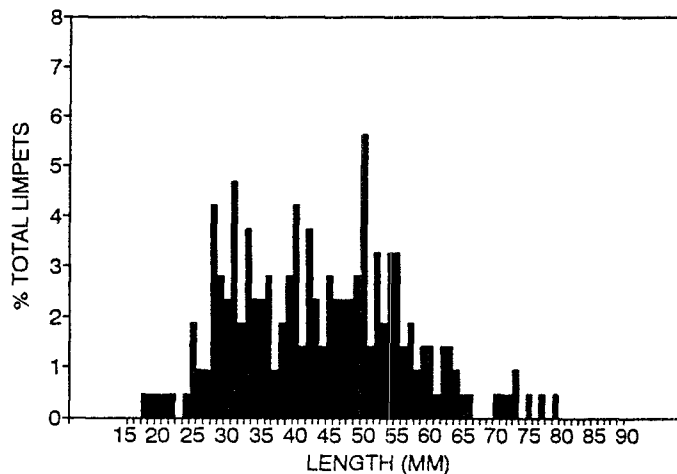
OWL LIMPET LENGTH FREQUENCY  
FOR AREA III DURING SPRING 1991



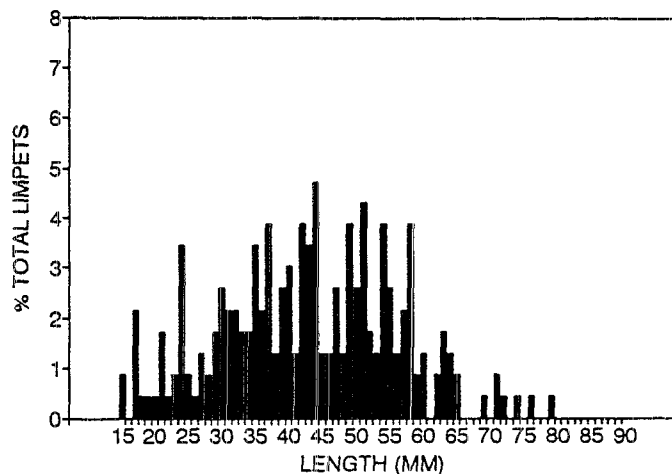
OWL LIMPET LENGTH FREQUENCY  
FOR AREA III DURING FALL 1991



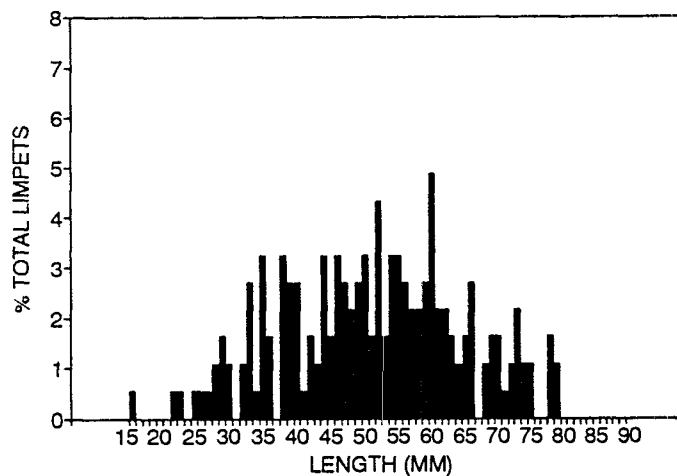
OWL LIMPET LENGTH FREQUENCY  
FOR AREA I DURING SPRING 1992



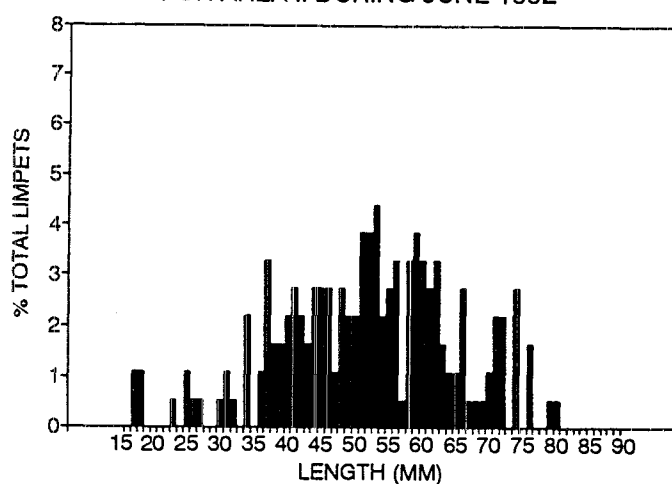
OWL LIMPET LENGTH FREQUENCY  
FOR AREA I DURING JUNE 1992



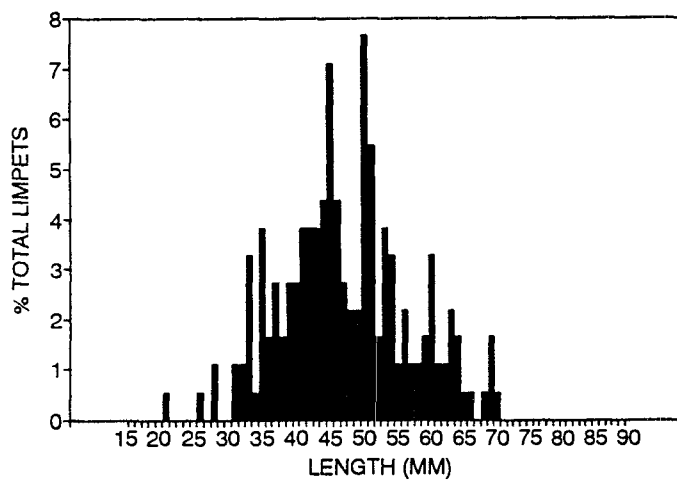
OWL LIMPET LENGTH FREQUENCY  
FOR AREA II DURING SPRING 1992



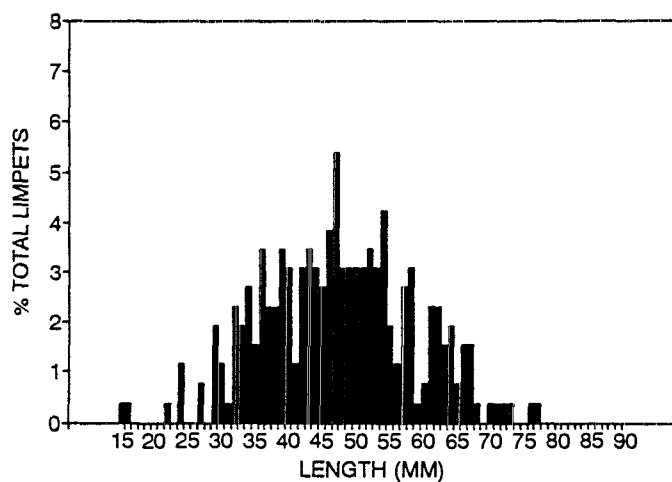
OWL LIMPET LENGTH FREQUENCY  
FOR AREA II DURING JUNE 1992



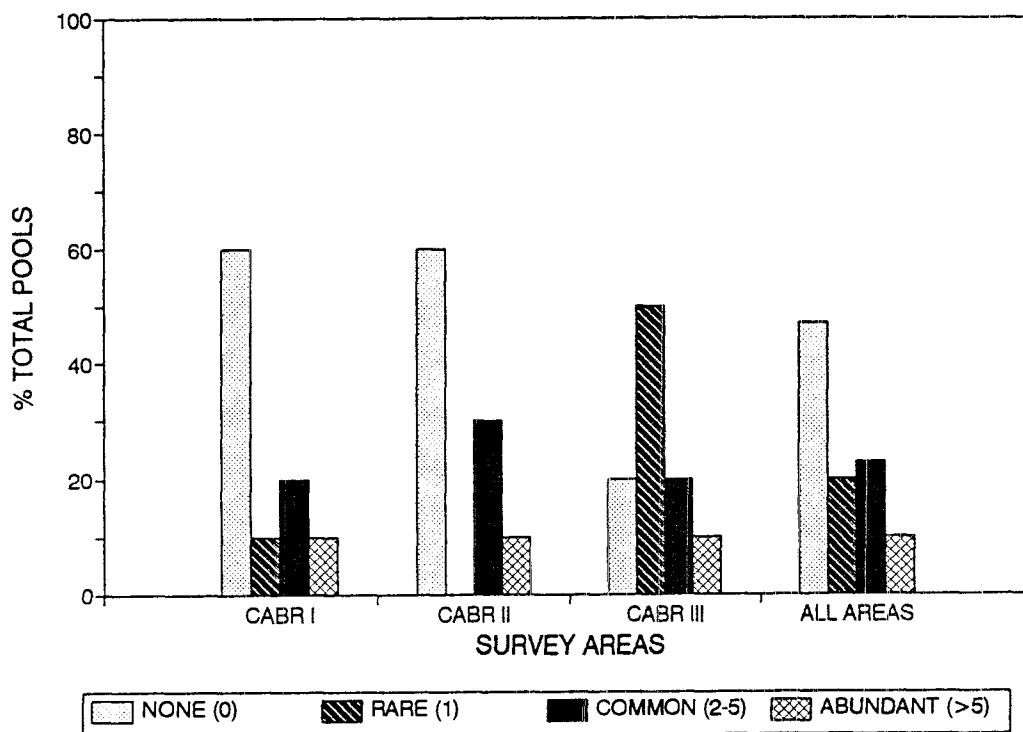
OWL LIMPET LENGTH FREQUENCY  
FOR AREA III DURING SPRING 1992



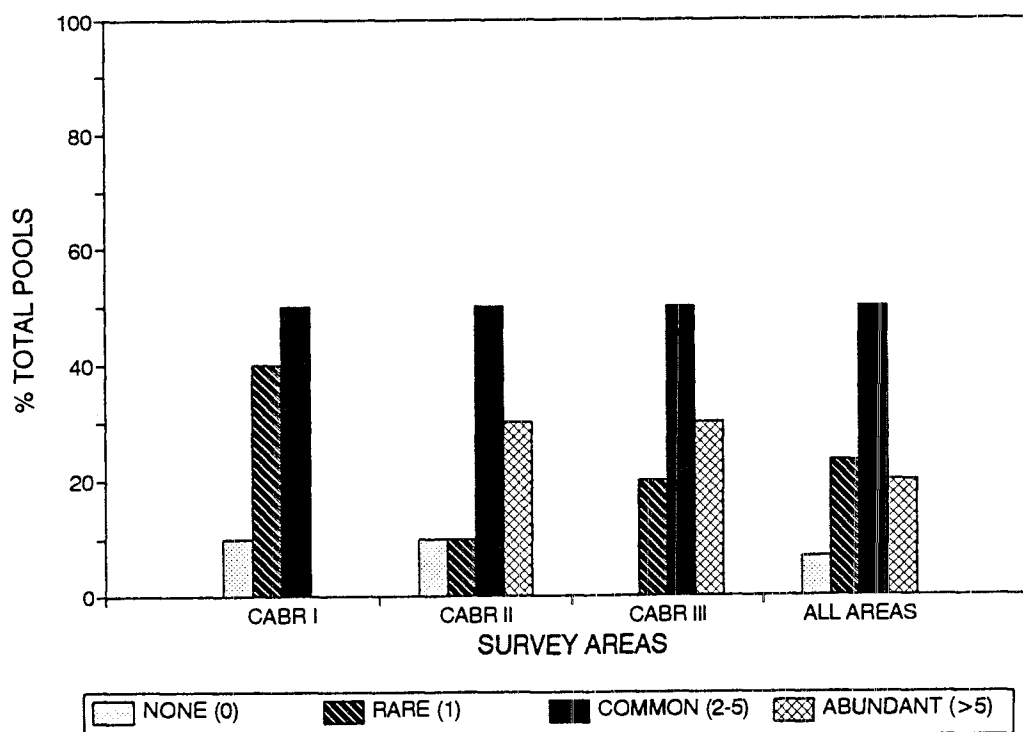
OWL LIMPET LENGTH FREQUENCY  
FOR AREA III DURING JUNE 1992

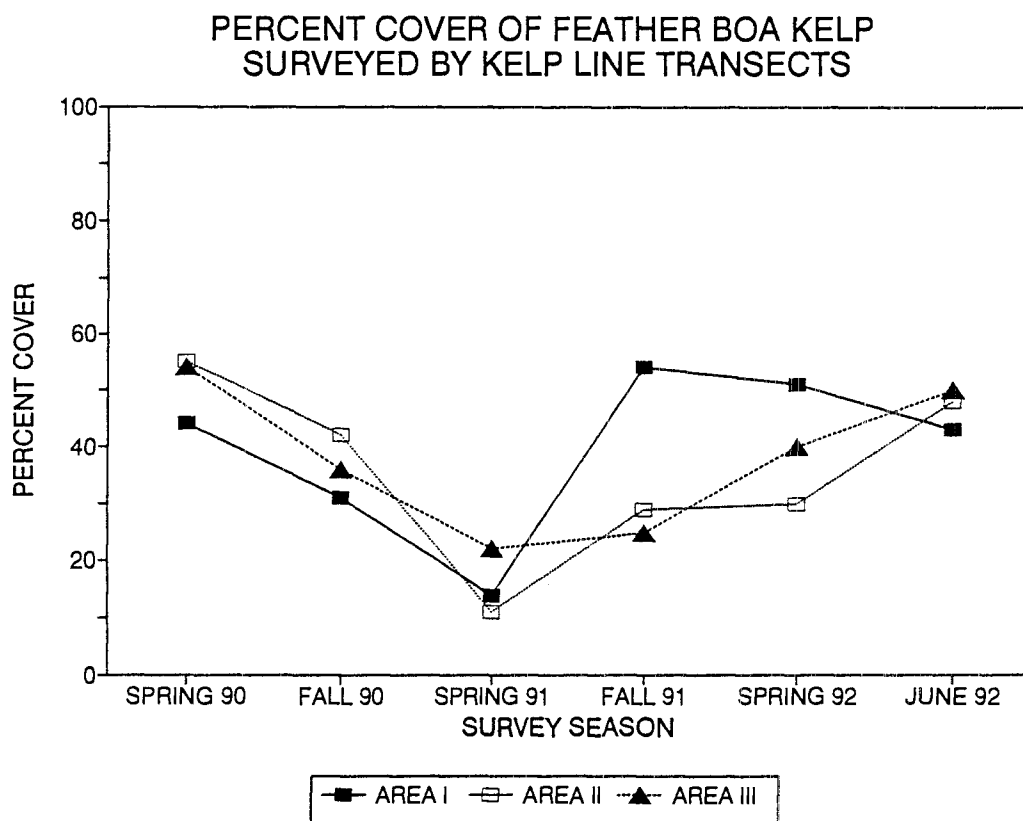
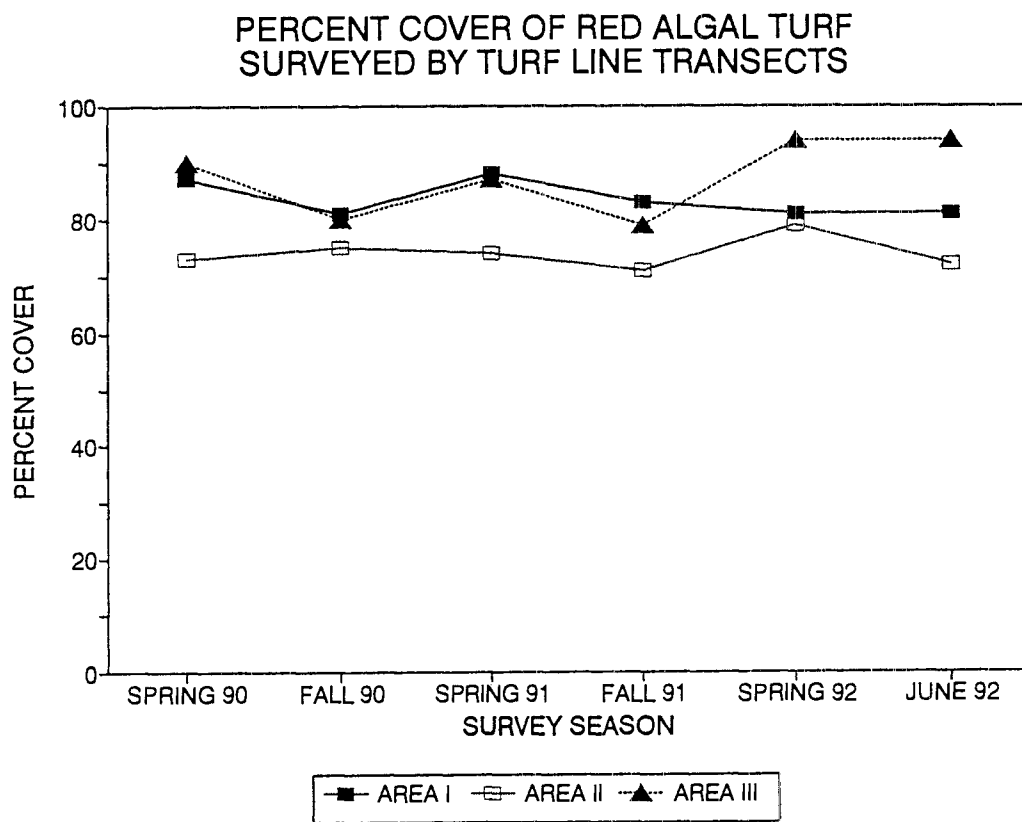


# RELATIVE ABUNDANCE OF WOOLLY SCULPINS IN POOLS AT CABRILLO NM IN SPRING 1992

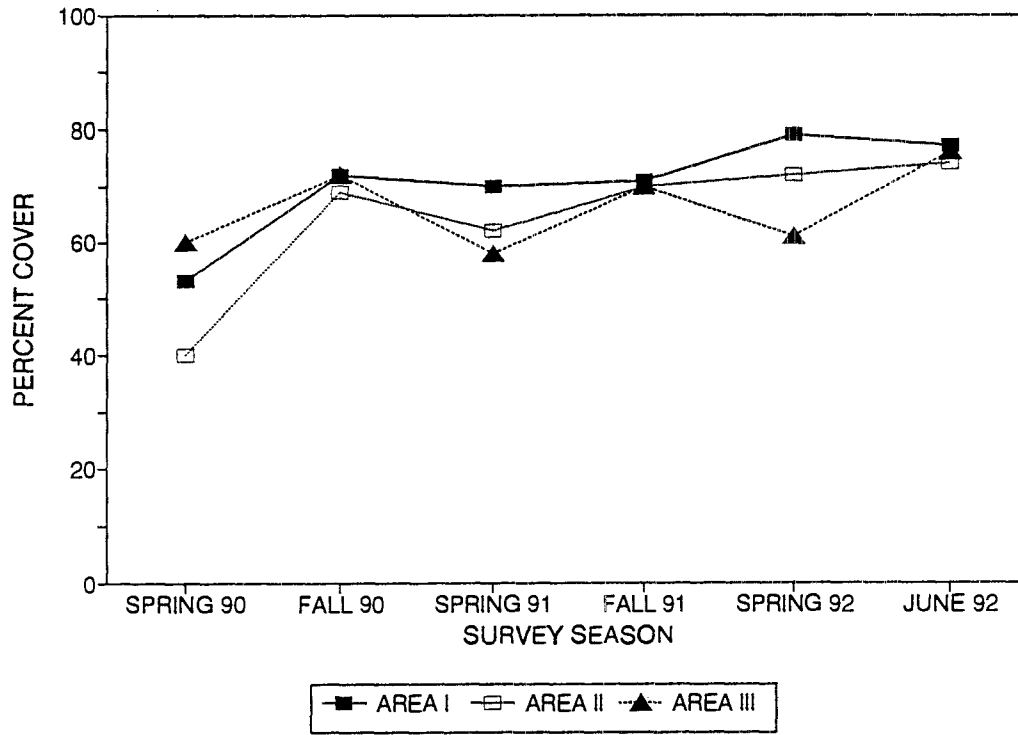


# RELATIVE ABUNDANCE OF WOOLLY SCULPINS IN POOLS AT CABRILLO NM IN JUNE 1992





### PERCENT COVER OF SURF GRASS SURVEYED BY GRASS LINE TRANSECTS



### PERCENT COVER OF SURF GRASS SURVEYED BY KELP LINE TRANSECTS

